Prepared by:

Environmental Assessments and Planning Policy Section

Pollution Policy Division,

Economic Assessments Policy Section

Pollution Policy Division

And

Environmental Standards Section

Business Strategy Division

Her Majesty's Inspectorate of Pollution

43 Marsham Street

London SW1P 3PY

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FOREWORD

When Integrated Pollution Control was first introduced in April 1991 only general guidance on how environmental assessments for IPC should be conducted was available. Several fundamental questions were posed by the legislation and accompanying regulations, i.e. how should an operator demonstrate that the choice of process represented the Best Practicable Environmental Option in accordance with section 7(7) of the Environmental Protection Act 1990? Also, what kind of environmental information should an operator provide to demonstrate that no harmful effects to the environment occur? And how should inspectors use this information in determining an IPC application?

Over the past 3 years HMIP has conducted research and carried out case studies with the aim of developing practical approaches to these aspects of IPC. Currently, there are three main areas of activity. First, as this document shows, we are developing principles for conducting environmental, economic and BPEO assessments for IPC. Second, we have taken steps to ensure that the tools for conducting assessments, such as predictive mathematical models and supporting data bases, are available to inspectors and that they are in the public domain. A recent seminar was held at HMIP to explore the potential for doing this via a consortium of regulators, operators and environmental groups. The third area is the introduction of more strategic (national) BPEO considerations in preparing Chief Inspectors Guidance Notes, so that only site specific considerations need be addressed by individual operators. Only in this way can we ensure that we fully meet those objectives of IPC relating to preventing and minimising harm and authorising the Best Practicable Environmental Option.

This document gives guidance on the principles for assessing harm and comparing options for specific industrial processes to determine the BPEO It also outlines the kind of economic information required as this is essential to gauge the practicality of process options. Taken with other information, such as fitness for purpose, training, operator competence etc., the net result of course should be the selection of the process and abatement option which represents BPEO in accordance with Section 7 of the Environmental Protection Act 1990.

DAVID SLATER
Director and Chief Inspector
Her Majesty's Inspectorate of Pollution.

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PREFACE

This consultation paper has been several years in the making. The Inspectorate recognised the need for practical guidance on conducting integrated environmental assessments for IPC as soon as the concept of achieving the Best Practicable Environmental Option (BPEO) was included in the Environmental Protection Bill. A special unit was established to develop conceptual thinking in this area, in particular, to develop principles for justifying the selection of the best practicable environmental option for IPC processes on a site specific basis. The first draft document was discussed within the Inspectorate in April 1992, and then within the Department of the Environment a few months later. After an encouraging response, further detailed case studies were carried out as well as research to develop the necessary standards. The procedure was also presented at an international workshop in Geneva where it commanded widespread interest, particularly in light of support within the OECD for an integrated approach to pollution prevention and control and moves within the European Commission towards adopting a similar integrated permitting approach to IPC.

In July last year the resultant draft guidance note was presented at a seminar organised by HMIP. In the audience were representatives from academia, industry and environmental organisations. The aim of the seminar was to give a preliminary airing of the proposals to outside bodies. The seminar provoked widespread response from participants. Several follow up meetings were held between HMIP and other organisations to explore specific issues. HMIP has take all comments into account in preparing this formal consultation document.

One of the main changes from the July 1993 version is the expansion of the number of factors taken into account in reaching a judgement on the Best Practicable Environmental Option. The need to do this was clearly recognised by the Royal Commission in their twelfth report (para. 3.23):

> 'The presentation of information, opinions and conclusions reached at different stages of the BPEO study is clearly important. The decision maker, and other persons, should be able to see separately the data or scores relating to each aspect of the decision for each option.'

The procedure has been modified to ensure that around half a dozen key aspects for each option are clearly presented, readily understood and informative. As in the July version, the main basis for assessing and ranking releases to air, water and (via air) to land is long term impact. Other factors to be taken into account in modifying this ranking include short term effects, global warming potential, ozone generation, assessment of solid and liquid waste arisings and any other relevant factors.

Other changes from the July paper include:

- guide Environmental Assessment Levels derived on a consistent basis for releases to air, water and deposition to land (via air) for use in evaluating whether or not releases are rendered harmless and for the BPEO assessment;

- a scheme for accounting for releases of solid and liquid waste arisings in determining the BPEO;

- more information on the kind of cost information required to justify the choice of BATNEEC/BPEO option.

We believe that the net result is a more robust methodology. Even with these refinements, the proposals represent a first iteration and further work is being carried out to refine the procedure, for example, to improve the consistency of the environmental assessment levels across different environmental media. We also propose to carry out a number of further detailed case studies involving operators and site inspectors to fully prove the system. In the meantime, your comments are invited on all or any of the issues raised and especially on the practicality of the procedure.

WHERE TO SEND RESPONSES

Please send two copies of your response **by 30th June** to:
Ms Linda Clark,
Her Majesty's Inspectorate of Pollution,
Room A5.04,
Romney House,
43 Marsham Street,
London SW1P 3PY.

Further copies of this consultation paper can obtained by contacting Linda Clark on 071-276 8899.

GLOSSARY OF TERMS

Term	Definition
Action Level	The concentration of a substance at a location, below which with present knowledge, the environmental consequences of a release can be considered negligible.
Ambient concentration	The existing concentration of a substance at a given location. In the case of existing processes, this will include the current process contribution.
Best Environmental Option	The option which, in the context of releases from the prescribed processes considered, provides the greatest benefit or least damage to the environment as a whole, irrespective of cost, in the long term as well as the short term.
Best Practicable Environmental Option	The (IPC) BPEO can be considered as; 'the option which in the context of releases from a prescribed process, provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as the short term.
Corrected ambient concentration	Ambient concentration minus the current contribution of the process.
Cost effectiveness analysis	The determination of the least-cost method or means of achieving a particular objective. Cost-effectiveness may also be expressed as the lowest cost per unit of objective achieved.
Environmental Quality Standard (EQS)	Concentration of a substance in the receiving environment which must not be exceeded if the environment is to be suitable for a particular purpose or use or to achieve a certain level of protection for a particular receptor(s). In the context of this report the term EQS has been applied only to statutory limits prescribed by the Secretary of State.

Term	Definition
Environmental Quotient$_{(Substance)}$ (EQ $_{(Substance)}$)	A dimensionless number derived by dividing the process contribution (PC) of a substance by the appropriate EQS or EAL
Integrated Environmental Index (IEI)	The sum of EQ $_{(medium)}$ for releases to air, water and via air to land.
Tolerable release	A release which results in a PEC which lies above the Action Level but below the EQS or EAL.
Total annualized cost	The measure of the cost of pollution control. Computed first by multiplying capital costs by an appropriate annualization factor based on the interest rate and the lifetime of the relevant process abatement techniques. This figure is then added to the typical operating and maintenance cost.

1 INTRODUCTION

1.1 INTEGRATED POLLUTION CONTROL

1. Part I of the Environmental Protection Act 1990 introduced a new system of Integrated Pollution Control (IPC) and provides the framework for controlling releases from industrial processes and ensuring compliance with EC Directives on pollution control. Her Majesty's Inspectorate of Pollution is responsible for regulating industry in accordance with IPC.

2. Under Section 6 of the Act no prescribed process may be operated without an authorization from HMIP. In determining an authorization, Section 7 of the Act requires HMIP to include conditions for achieving the objectives set out in Section 7(2). These objectives are to ensure that in carrying out a prescribed process the Best Available Techniques Not Entailing Excessive Cost (BATNEEC) will be used:

   (i) for preventing the release of substances prescribed for any environmental medium into that medium, or where that is not practicable by such means, for reducing the releases of such substances to a minimum and for rendering harmless any substances which are so released; and

   (ii) for rendering harmless any other substances which might cause harm if released into any environmental medium.

3. Furthermore, where the process is designated for control by HMIP and involves the release of substances into more than one environmental medium, Section 7(7) of EPA 90 requires that BATNEEC will be used:

(iii) for minimising the pollution to the environment as a whole having regard to the Best Practicable Environmental Option (BPEO) available as respects the substances which may be released.

4. In addition, Section 7(2) requires that conditions should be placed within an authorization to ensure that releases do not cause, or contribute to the breach of:

(iv) any direction given by the Secretary of State to implement European Community or international obligations relating to environmental protection,

(v) any statutory environmental quality standard or objectives or other statutory limits or requirements.

1.2 PURPOSE OF THE DOCUMENT

5. The requirements set out in Section 7 of the Act indicate that the principle objective of Integrated Pollution Control should be the prevention of releases and hence avoidance of pollution rather than the application of secondary abatement measures. However, it is recognised that for many processes there will be unavoidable releases and alternative process options may lead to variations in the spectrum of releases to different media. Under these circumstances it will be necessary to predict and evaluate the environmental consequences of releases and weigh them against the costs of appropriate primary or secondary control measures in order to determine the site specific BATNEEC/BPEO. The purpose of this document is, therefore, to:

i) outline a practical and efficient approach to assessing the environmental consequences of unavoidable releases which can be used by operators in the preparation of applications for authorisation under IPC;

ii) provide guidance to Inspectors on the technical assessment of environmental information provided by operators; and

iii) provide guidance to Inspectors and operators on the identification of the Best Practicable Environmental Option (BPEO) where there are releases to more than one environmental medium.

6. Although the document is primarily intended to provide guidance to HMIP Inspectors, it is anticipated that by setting out the basis on which environmental information will be assessed, operators will be able to present their applications more effectively, with subsequent savings of time and effort for both them and HMIP. However, it is recognized that site specific circumstances may require a variety of assessment techniques to be used by operators in preparing their applications. The methodology described in subsequent sections of this document should, therefore, not be considered as prescriptive.

7. It is also recognized that the detailed assessment of releases from a prescribed process may be complex and that there will be considerable uncertainties surrounding much of the information required, or in some cases data may not be available at all. In preparing this document, therefore, consideration has been given to the necessity to develop a practical approach which can be implemented with our present understanding and refined in the future as new techniques and further information become available.

8. It is intended that a number of Technical Notes will be produced to provide more detailed information on specific topics.

2 ASSESSMENT OF HARM AND BPEO UNDER INTEGRATED POLLUTION CONTROL

2.1 ASSESSMENT APPROACH

9. A prescribed process should be consistent with best practice set out in the appropriate Chief Inspector's Guidance Note. The techniques to be employed may be those described in the Note or alternatives which enable the same or better standards to be achieved. In any IPC application an operator should indicate the range of process/abatement options considered from which the final preferred option has been selected.

10. The environmental consequences of the different process options should be assessed and the option which represents the **Best Environmental Option** (BEO)[1] identified. Where the operator's preferred option does not represent the Best Environmental Option as indicated by this procedure, the choice would need to be fully justified. It is expected that the justification will largely be based on the consideration of excessive cost in relation to the environmental benefits of the preferred and rejected options.

11. Once the site specific BATNEEC/BPEO has been determined the selected option can be implemented. In the case of new plant this might be expected to take effect from the outset, whereas, for existing plant an improvement programme over a specified time period may need to be agreed with the operator.

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[1] See glossary for definition.

2.2 DEFINITION OF HARM

12. It is clear from the objectives given in section 7 of EPA 90 that a means for assessing harm is required by HMIP for use in making regulatory judgements. Within the context of the Act 'harm' means:

> 'harm to the health of living organisms or other interference with the ecological systems of which they form a part and, in the case of man, includes offence caused to any of his senses or harm to his property; and harmless has a corresponding meaning'.

13. However, the Act does not define the nature of the effects which may be considered harmful or the level in the environment at which they may occur. Therefore, HMIP has developed a practical approach to the assessment of harm. This is described in the following section.

2.3 ASSESSMENT OF HARM

14. The environmental consequences of a particular process will depend on a number of factors. These include the magnitude of the releases, ambient pollutant concentrations, as well as the composition, structure, response and function of the receiving environment.

Complete knowledge of this type is rarely available. However, there is a considerable amount of laboratory and ield based data on the sensitivity of individual eptors[2] to particular pollutants.

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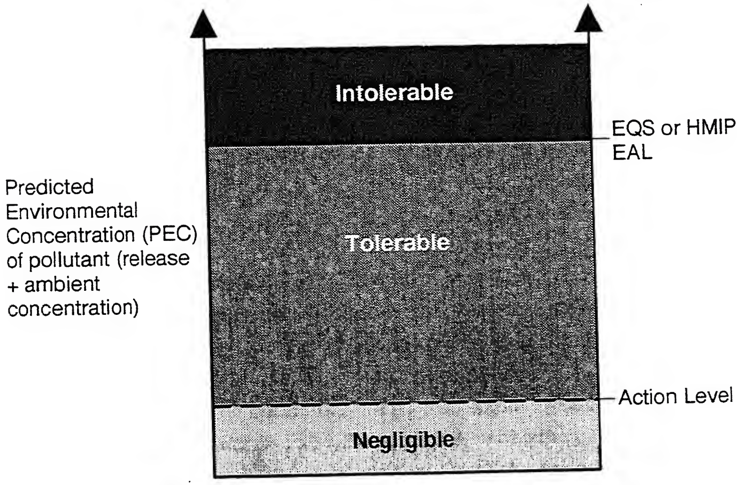
ion receptor is often used to describe that part of the environment ed to a pollutant.

16. This information has formed the basis for the development of environmental quality objectives and standards such as those used in water quality control. Environmental criteria of this type provide a 'benchmark' against which the relative harm/harmlessness of releases from prescribed processes can be assessed. The proposed method for assessing the level of harm caused by individual releases to a single medium is illustrated in Figure 2.1.

Figure 2.1 Basis for Decisions on the Tolerability of Releases


Intolerable
EQS or HMIP EAL
Predicted Environmental Concentration (PEC) of pollutant (release + ambient concentration)
Tolerable
Action Level
Negligible

17. The **Intolerable Level** is defined by a statutory limit such as an Environmental Quality Standard (EQS). In the absence of an EQS or a standard set down in a direction from the Secretary of State, an Environmental Assessment Level (EAL) will be identified by HMIP. The EAL provides

guidance to HMIP's Inspectors on the maximum environmental concentration of a substance above which unacceptable harm may occur. EALs may be expressed as either long term or short term values depending on the nature of the release being assessed and on the nature of the receiving environment.

18. A release which results in a predicted environmental concentration (PEC) greater than a statutory EQS or HMIP EAL is considered unacceptable and an alternative process or abatement option should be sought. Where the operator is unwilling or unable to comply with the EQS then an authorization may not be granted. Where the release leads to a breach of an EAL refusal of the authorization may also be considered in seeking the process option which represents BATNEEC/BPEO for the site.

19. A release which results in an environmental concentration above the **Action Level** can be considered **tolerable** and BATNEEC should be used to prevent, minimise and render harmless prescribed substances and render harmless any other substances.

20. The Action Level represents a concentration below which, with present knowledge, environmental effects can be considered negligible.

21. In the long term it is intended that habitat and/or receptor specific EALs will be defined on a consistent basis through HMIP's research programme. In the interim provisional environmental assessment levels representing a particular medium as a whole, have been derived from a variety of published United Kingdom and international sources. The derivation of EALs and Action Levels is discussed in more detail in Annex A along with the first set of guide values.

2.4 EVALUATION OF BEST PRACTICABLE ENVIRONMENTAL OPTION (BPEO)

2.4.1 Definition of BPEO

22. Where a process involves the release of substances to more than one environmental medium, the Inspector will need to determine whether the proposed operation represents the BPEO for the pollutants concerned. As EPA 90 does not define the BPEO, it is proposed to adapt the definition given by the Royal Commission on Environmental Pollution in their Twelfth Report (HMSO, 1988) to the requirements of IPC i.e.

> The (IPC) BPEO can be considered as: **'the option which in the context of releases from a prescribed process, provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as the short term.'**

2.4.2 Best Practicable Environmental Option Selection Procedure

23. The Royal Commission on Environmental Pollution described a BPEO as "the outcome of a systematic consultative and decision-making procedure which emphasised the protection and conservation of the environment across land, air and water. It also described how to select a BPEO and the steps involved were summarised under the following headings:

i. define the objective;

ii. generate options;

iii. evaluate options;

iv. summarise and present the evaluation;

v. select the preferred option;

vi. review the preferred option;

vii. implement and monitor;

and throughout all these steps: maintain an audit trail.

24. This procedure has been adapted in developing the framework described in this document for generating IPC process options for evaluating the site specific Best Practicable Environmental Option.

2.4.3 Framework for Identification of the Site Specific BPEO

25. To determine the site specific BPEO a wide range of factors need to be taken into account, for example:

- o long term local and remote environmental effects;
- o Short term environmental effects (usually local to the site);
- o global atmospheric effects (eg, greenhouse or ozone generation potentials);
- o disposal or recycling of liquid and solid wastes;
- o process practicality and efficiency; and
- o costs of process or abatement options.

26. The integrated assessment of these factors is complex and given their different characteristics must inevitably rely on professional judgement to identify the BPEO. To ensure that the decision making process is carried out in a

transparent and consistent manner, an assessment framework has been developed to enable relevant factors to be taken into account. Part of this framework entails deriving an Integrated Environmental Index (IEI) to enable different process options to be ranked according to their relative **long term** environmental effects.

27. The environmental consequences of a pollutant will depend on the magnitude of the release, ambient pollutant concentrations and the nature of the receiving environment. In considering alternative process options at a particular location the ambient pollutant concentrations and nature of the receiving medium will effectively be the same for all process options. The relative environmental consequences of different process options will, therefore, be related to the magnitude of the release. However, an Integrated Environmental Index based solely on the magnitude of a release does not take into account the relative hazard represented by different substances. This can be overcome by normalizing the release in relation to an environmental quality criterion such as an EQS or HMIP EAL.

28. On this basis, the index for a particular process can be calculated as follows:

$$\mathit{Integrated\ Environmental\ Index}_{(process)} = \sum_{m=1}^{j} \sum_{s=1}^{i} \frac{\mathit{Plant\ contribution}_{s,m}}{EQS_{s,m}\ \mathit{or}\ EAL_{s,m}}$$

29. Where process contribution $_{(s,m)}$ represents the maximum long term average environmental concentration of substance (s) released to medium (m).

30. If the index is calculated for a range of process and abatement options at a site, then they may be ranked according to the long term environmental effects of the

releases. The option for which the index is a minimum could be considered the Best Environmental Option (BEO).

31. The index can then be considered in conjunction with other environmental factors (as outlined in paragraph 25) to modify the ranking. This in turn can be used with economic information to identify the BPEO.

3.0 ENVIRONMENTAL ASSESSMENT PROCEDURE FOR IPC

3.1 PURPOSE AND SCOPE OF ASSESSMENT PROCEDURE

32. The previous section set out the basis on which HMIP will assess the environmental consequences of releases from prescribed processes and the factors which should be taken into account in determining the BPEO. Subsequent sections of this document describe the framework for applying the approach to the technical assessment of applications. The level of information provided by the operator and the depth of assessment carried out by the Inspector will be dependent on the nature of the process being considered.

33. The position of the technical assessment in relation to the general authorization process is illustrated in Figure 3.1. The technical assessment of an application involves consideration of a wide range of factors including the technology involved, operational, management and monitoring techniques to be employed at the site as well as an assessment of the environmental consequences of releases from the process.

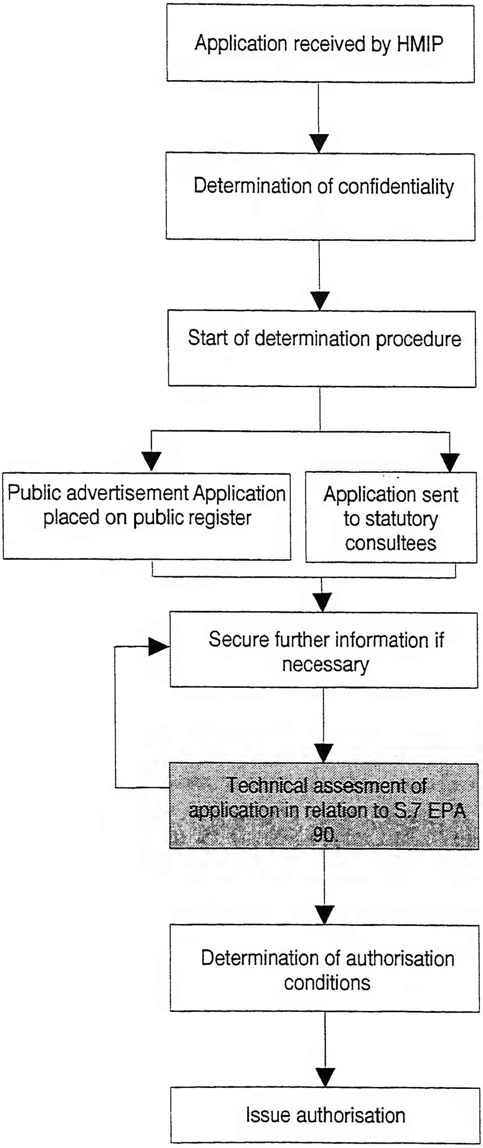
34. The purpose of this procedure is to provide a framework within which the Inspector is able to:

    i) identify whether the operator has provided sufficient information in the application to enable the environmental consequences (level of harm) of releases to be properly assessed;

    ii) derive technical information on the tolerable level of releases in order to:

        a) assess alternative process options;

Figure 3.1 Application Determination and Authorisation Procedure for IPC.


Application received by HMIP
Determination of confidentiality
Start of determination procedure
Public advertisement Application placed on public register
Application sent to statutory consultees
Secure further information if necessary
Technical assesment of application in relation to S.7 EPA 90.
Determination of authorisation conditions
Issue authorisation

ADMINISTRATIVE STEPS

Application allocated unique reference number and fee received.

If required, determination of application for commercial confidentiality or national security within 14 days.

Determination period 4 months from receipt of application or date confidentiality determined applicable.

Application sent for consultation to statutory consultees within 14 days.

TECHNICAL ASSESSMENT

Assess comments received and obtain further information if necessary.

Evaluate process options, environmental consequences, operational/management techniques.

DETERMINATION

Determine BATNEEC, BPEO and compliance with S.7 EPA 90. Consider release limits, compliance and monitoring conditions to be set. Agree improvement programme and timetable for existing plant Prepare formal authorisation.

b) direct regulatory effort to greatest effect; and

c) determine the requirement for environmental monitoring; and

iii) ensure that the process or abatement option chosen represents BATNEEC and the site specific BPEO.

35. Moreover, as discussed in Section 2.4.2, it is intended that the procedure will enable the determination of the site specific BATNEEC/BPEO to be carried out in a structured, transparent and consistent manner. The procedure also provides an audit trail for the technical assessment of the operator's environmental submissions and as such should be followed for all applications received under IPC.

3.2 ASSESSMENT PROCEDURE

36. The assessment procedure can be broken down into three main stages i.e.

STAGE 1: PRELIMINARY ASSESSMENT OF BASE CASE[3] AND GENERATION OF ALTERNATIVE PROCESS AND ABATEMENT OPTIONS.

A preliminary assessment of the performance of the base case operation with respect to release levels, compliance with environmental quality standards and the potential environmental consequences of the releases, to enable practicable process or abatement options to be identified for further evaluation.

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[3] The base case can be an existing plant or a basic new facility.

STAGE II: ENVIRONMENTAL ASSESSMENT OF BASE CASE AND OTHER PRACTICABLE PROCESS OR ABATEMENT OPTIONS

Assessment of the environmental consequences of releases, harm over the short and long term, global warming potential, ozone generation potential and waste arisings, to rank the options and identify of the Best Environmental Option.

STAGE III: DETERMINE SITE SPECIFIC BPEO

Selection of site specific BPEO based on a comparison of costs if the Best Environmental Option is not proposed.

37. The environmental assessment will form part of the IPC application and will, therefore, be included in the public register. In order that the assessment can be readily understood and evaluated by the Inspector and be amenable to independent public scrutiny, an 'audit trail' listing the sources of information, methods of calculation and any assumptions made, should be provided by the operator.

4.0 STAGE 1: PRELIMINARY ASSESSMENT OF 'BASE CASE' AND GENERATION OF ALTERNATIVE PROCESS AND ABATEMENT OPTIONS FOR BPEO ASSESSMENT.

4.1 PRELIMINARY ASSESSMENT PROCEDURE

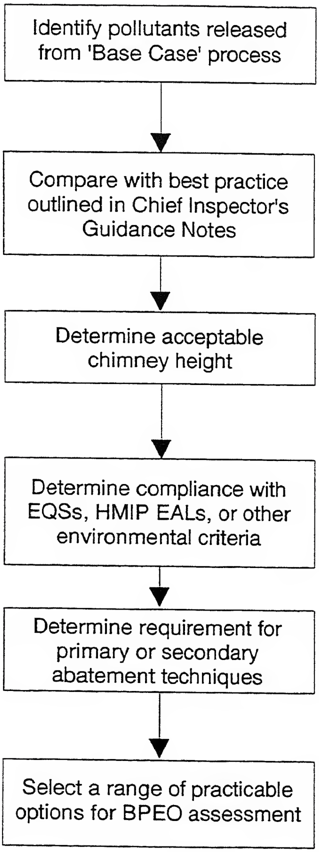
38. The generation of appropriate process and abatement options for BPEO assessment should be carried out in a structured manner to ensure that potential options are not overlooked and that the requirements of section 7 of EPA 90 will be met. Adopting such an approach enables the justification of the choice of particular techniques to be communicated clearly to HMIP, statutory consultees as well as other interested organisations or individuals.

39. In the case of new plant there will be scope to consider a wide and fundamental range of options. However, it is recognized that for existing processes the practicable range of alternative options which can be implemented may be constrained by plant specific conditions, such as the nature of the existing process, site layout or planning requirements.

40. The selection of practicable options should be based on a preliminary assessment of the existing process or in the case of a new process, the consequences of the unabated releases; i.e. the 'base case' process. Deficiencies in environmental performance can be identified and appropriate combinations of primary control or secondary abatement techniques can be generated as options for further evaluation.

41. The recommended procedure for generating process/abatement options for BPEO assessment is illustrated in Figure 4.1 and further guidance is provided in the following sections of this chapter.

Figure 4.1 Preliminary (Stage I) Assessment of Base Case and Generation of Practicable Process and Abatement Options for BPEO Assessment.



PROCEDURE	COMMENTS
Identify pollutants released from 'Base Case' process	For the base case process, identify and quantify the release of prescribed and other pollutants.
Compare with best practice outlined in Chief Inspector's Guidance Notes	Compare releases from process with those achievable through the application of best practice for existing processes and new processes.
Determine acceptable chimney height	Carry out stack height determination, see page 18 and guidance in HMSO (1993).
Determine compliance with EQSs, HMIP EALs, or other environmental criteria	Determine ambient concentration and predict plant contribution for pollutants released. Assess compliance with EQSs or other environmental criteria.
Determine requirement for primary or secondary abatement techniques	Determine where additional process or abatement controls are required, or where reductions can readily be made.
Select a range of practicable options for BPEO assessment	Generate a range of process and abatement options to give the required control of pollutants for BPEO assessments under Stage II.

4.2 IDENTIFY POLLUTANTS RELEASED FROM PROCESS

42. All substances released from the basic process should be identified irrespective of magnitude. Substances other than prescribed substances should be included since section 7(2) of EPA 90 requires that BATNEEC be used for rendering harmless other substances which may cause harm if released into any environmental medium. Guidance on the substances released from the process can be found in the relevant Chief Inspector's Guidance Note.

43. Sufficient information should be provided by the operator to enable the extent of the releases to be quantified. The information should include:

    i) the concentration of pollutant in the discharge stream;

    ii) proposed emission rate (quantity per unit time); and

    iii) an estimate of the total annual load released.

44. Where mean concentrations are provided they should be expressed as flow weighted averages. The above information should be sought for the following operating conditions:

    i) peak discharges, which may be as a result of periodic fluctuations in the plant throughput or a consequence of start-up or shut-down operations;

    ii) proposed normal operating conditions;

    iii) fugitive emissions; and

    iv) expected but unplanned releases, for example, releases from safety valves or overflow weirs.

45. In the case of discharges to sewer, this information should be supplied, together with an estimate of the final load discharged to the receiving water. Information on typical removal rates of the pollutant during sewage treatment can be obtained from the local water company. The removal rates assumed should be clearly stated in the data supplied.

4.3 COMPARISON WITH CHIEF INSPECTOR'S GUIDANCE NOTES

46. The releases identified in the previous section should be compared with the requirements of the relevant Chief Inspector's Guidance Note. The extent of control measures which would enable compliance with these standards can then be identified. These might simply be expressed as the percentage reduction required for a particular substance to meet the standards set out in the guidance document.

4.4 CHIMNEY HEIGHT DETERMINATION

47. Where releases occur to the atmosphere operators should demonstrate that the current chimney height provides adequate dispersion for the pollutants produced. Guidance on the assessment of chimney heights is provided in Technical Guidance Note (Dispersion) D1 (HMSO 1993). The assessment of chimney heights will also provide some information on the relative importance of different substances for control.

48. Where the calculations indicate that the current chimney height is inadequate then further calculations should be undertaken to identify the level of control required to ensure adequate dispersion through the existing stack.

4.5 DETERMINATION OF COMPLIANCE WITH ENVIRONMENTAL QUALITY STANDARDS, REQUIREMENTS OF THE SECRETARY OF STATE OR HMIP ENVIRONMENTAL ASSESSMENT LEVELS

49. The operator should demonstrate for each release that the environmental concentration of the pollutant, including the process contribution, does not exceed the relevant Environmental Quality Standard (EQS) or in the absence of an EQS, the HMIP guide Environmental Assessment Level (EAL). If a release would lead to a breach of the EQS or EAL, then the required level of control for the pollutants concerned should be determined.

50. The Inspector should confirm that the operator has properly identified the relevant EQSs or standards set down in Directions made by the SoS for the receiving medium concerned. Where a number of EQSs apply to a particular medium or location the most stringent standard should be met. **Guidance on the EQSs and HMIP EALs to be applied is provided in Annex A.**

51. In addition to compliance with relevant EQSs or HMIP EALs, operators should consider the consequences of releases on any particularly sensitive pollution receptors in the receiving environment. Examples of sensitive receptors may include: Sites of Special Scientific Interest (SSSIs); other industrial or commercial activities with particular environmental quality requirements (eg fish farms); buildings (eg hospitals); or particular substance/receptor combinations, such as the effects of fluoride on cattle. An assessment of the likely effects of the release on the receptor concerned should be undertaken and if necessary the level of control required to render the release harmless should be identified.

4.6 IDENTIFICATION OF SIGNIFICANT RELEASES

52. The assessment of the process contribution to the predicted environmental concentration can be undertaken with varying degrees of complexity. For practical reasons, where ambient pollutant concentrations are below the relevant action level for the release, then it may be appropriate to use relatively simple methods, such as, dilution factors or nomograms to estimate the process contribution. However, these methods may have a large degree of uncertainty attached to their predictions. Therefore where ambient concentrations are high or the process contribution is expected to be relatively large, more sophisticated techniques may be necessary. In some cases it may also be necessary to take into account other factors such as the persistence or volatility of a substance in predicting the environmental concentration.

53. In selecting an appropriate level of assessment, the guiding consideration should be the relative importance of the release in determining the overall environmental consequences of the process. For many processes the environmental effects on a particular medium are likely to be dominated by the release of several 'significant' pollutants and the requirement for any abatement techniques will be driven by the need to control these substances.

54. As a rule of thumb, a significant release is one where the predicted environmental concentration is greater than the Action Level. The corollary is that releases resulting in an environmental concentration below the Action Level can be considered insignificant. Guidance on Action Levels for releases is given in Annex A (see also sections 2.3 and 5.2).

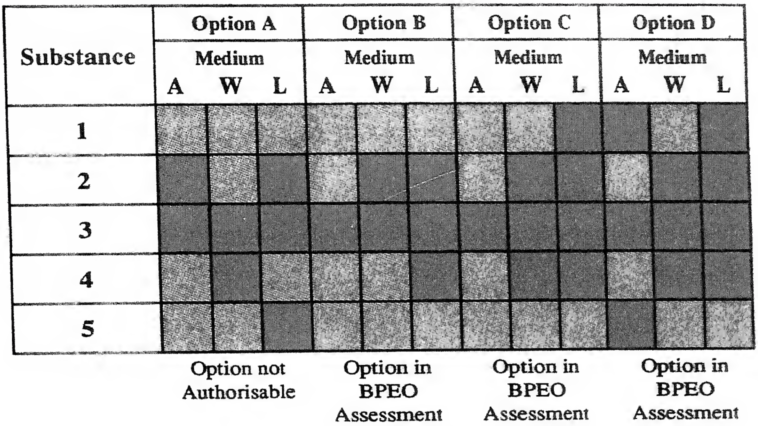
4.7 SELECTION OF PRACTICABLE PROCESS TECHNIQUES FOR BPEO ASSESSMENT

55. The level of control required for releases into each medium should be identified from the above assessments. A range of primary process and, where appropriate, abatement techniques to enable the required level of control to be achieved should be generated. Guidance on techniques can be found in the Chief Inspector's Process Guidance Note for the industry concerned. Individual techniques can be combined into a number of different overall process and abatement options which deal with the range of substances identified.

56. Where the previous assessment has indicated that a breach of an EQS is likely to occur, techniques should be selected which will enable compliance with the limit. If the operator is unable or unwilling to reduce releases sufficiently to enable compliance with the EQS then the authorization should not be granted.

57. To communicate clearly the generation of process/abatement options it is recommended that the predicted environmental concentration for each option be summarised on the basis of whether the PECs are negligible (green), tolerable (amber) or intolerable (red) as illustrated in Figure 4.2. Ideally all boxes in the matrix for the generated options should be green i.e. where the PEC is below the Action Level, but in practice there are likely to be a number of significant releases. Options where PECs lead to a breach of an EQS and are thereby rejected may also be illustrated.

Figure 4.2 Generation of Process Options (A D) For BPEO Assessment (Stage II)

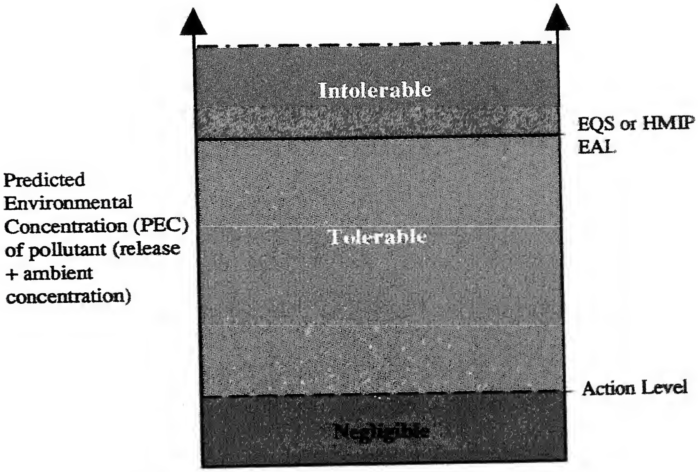

Substance
Option A
Option B
Option C
Option D
Medium
A W L
1
2
3
4
5
Option not Authorisable
Option in BPEO Assessment
Option in BPEO Assessment
Option in BPEO Assessment

▨ Intolerable (Red) Zone ie PC+AC >EAL

░ Tolerable (Amber) Zone ie EAL >PC+AC >AL

■ Negligible (Green) Zone ie AL >PC+AC

A - Air
W - Water
L - Land


Intolerable
EQS or HMIP EAL
Predicted Environmental Concentration (PEC) of pollutant (release + ambient concentration)
Tolerable
Action Level
Negligible

58. Table 4.1 illustrates the selection of appropriate techniques for the control of releases to air from an hypothetical process. It shows that the current process performance results in emission concentrations which are worse than those achievable through the application of BATNEEC and which are likely to be environmentally significant. The shortfall in performance can be used to identify the appropriate level of control. The techniques suggested in this example are purely illustrative. Similar tables could be prepared showing the selection of control techniques for substances released to other media.

Table 4.1 Hypothetical example illustrating the selection of techniques for the control of releases to air.

Substance	Release achievable by application of BATNEEC	Current plant performance	Environmental significance	% control required	Appropriate techniques
Particulates	50	200-1700	Yes	97	Electrostatic precipitator Bag filter
SO_2	750	19	No	-	-
NO_x	2700	24250-37000	Yes	99	Primary control measures with:- Selective catalytic reduction, or Selective non-catalytic reduction
HF	5	530-1425	Yes (Fluoride in grass)	>99	Wet scrubber Spray dry adsorption Semi dry adsorption

Substance	Release achievable by application of BATNEEC	Current plant performance	Environmental significance	% control required	Appropriate techniques
Pb	25	0.35–50	No	50	As for particulate removal or acid gas control.
Cd	1	nd	No	–	
As + Ni + Se + Sb + Cr + Cu	5	5–130	Yes	96	
Mn + V + Sn	25	nd–37	Yes	32	

5.0 STAGE II: ENVIRONMENTAL ASSESSMENT OF GENERATED PROCESS CONTROL AND ABATEMENT OPTIONS

5.1 ENVIRONMENTAL ASSESSMENT PROCEDURE

59. The wider environmental consequences of the alternative process options generated under Stage I should be assessed and the results used to identify the site specific Best Environmental Option (BEO). The proposed procedure for conducting environmental assessments of the options generated under Stage I is illustrated in Figure 5.1. Guidance on the assessment of releases from these options is provided in the following sections.

5.2 ASSESSMENT OF LONGER TERM ENVIRONMENTAL EFFECTS

60. The long term effects of a release[4] are considered the most robust means of evaluating the harmful effects of releases. For this reason the assessment of long term effects of releases represents the cornerstone of the methodology.

61. The long term consequences of a release will depend on its magnitude, the ambient pollutant concentration and the characteristics of the receiving environment, especially SSSIs.

62. For each process option the environmental consequences of single releases to each medium should be set out. In doing this it may be helpful to create a number of simple histograms which illustrate the magnitude of the release in

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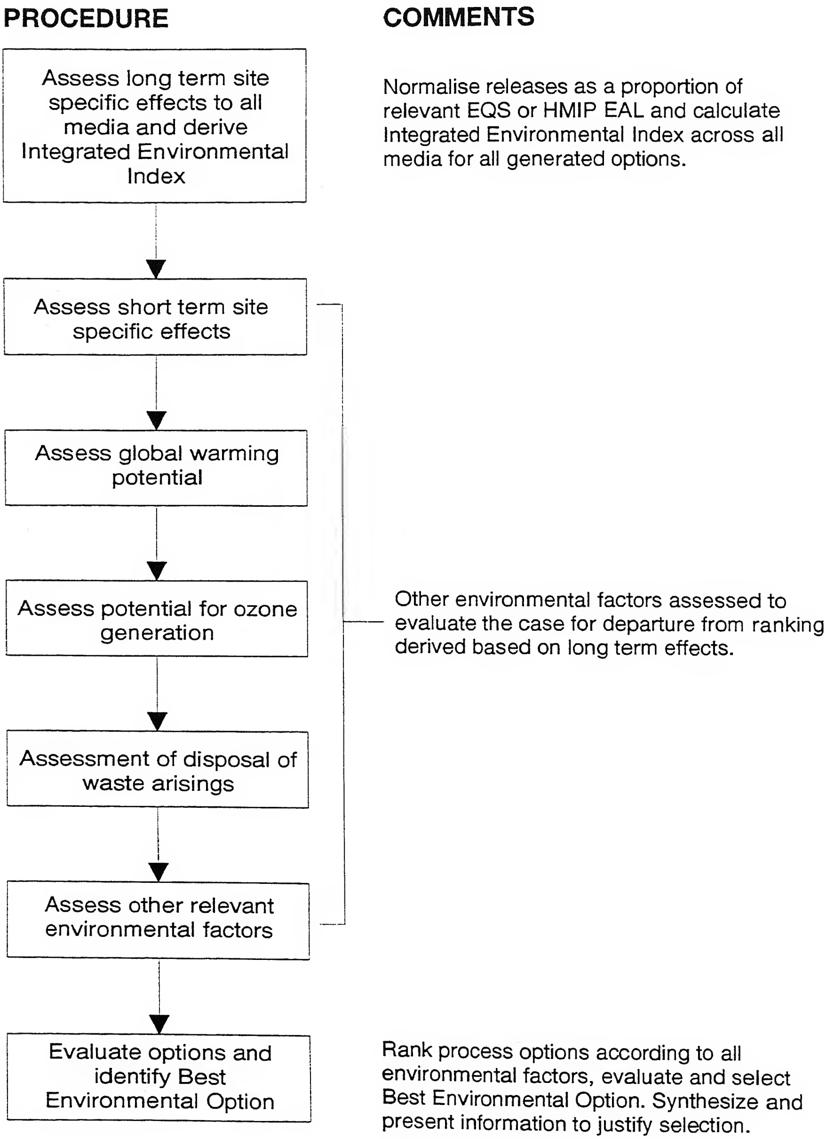
[4] For the purposes of this assessment procedure the long term environmental effects are those taking place as a result of exposure to pollutants over periods of a year or more. The exposure can therefore be assessed on the basis of annual average concentrations. (Short term effects on the other hand are considered to be those taking place as a result of exposures over periods significantly less than a year, typically hours or days).

Figure 5.1 Environmental Assessment of Process Control and Abatement Options Generated Under Stage I


PROCEDURE
COMMENTS
Assess long term site specific effects to all media and derive Integrated Environmental Index
Assess short term site specific effects
Assess global warming potential
Assess potential for ozone generation
Assessment of disposal of waste arisings
Assess other relevant environmental factors
Evaluate options and identify Best Environmental Option

Normalise releases as a proportion of relevant EQS or HMIP EAL and calculate Integrated Environmental Index across all media for all generated options.

Other environmental factors assessed to evaluate the case for departure from ranking derived based on long term effects.

Rank process options according to all environmental factors, evaluate and select Best Environmental Option. Synthesize and present information to justify selection.

relation to the ambient concentration and any relevant EQS, HMIP EAL, or other environmental criteria which may provide protection to a local sensitive pollution receptor.

63. For single releases to a medium the diagram could be expressed in absolute terms as illustrated in Figure 5.2

64. Where there are multiple releases to a medium their magnitude could be presented as a proportion of the relevant environmental criteria, as illustrated in Figure 5.3.

65. A diagram of this type enables the importance of different releases to be identified in relation to the EQS, HMIP EAL or existing ambient concentrations. For example, in the situation illustrated in Figure 5.3, the concentration of SO_2 is close to the EQS and exceeds local guideline levels for the protection of a sensitive receptor. It is clear that the process makes a major contribution to SO_2 levels in the area and may give rise to significant adverse effects. Information of this type can be derived for the other process options being considered and taken into consideration when selecting the BPEO.

66. As different process options give rise to different patterns of releases some quantitative method for comparing the different process options is required. The Integrated Environmental Index outlined in section 2.4.2 provides a mechanism for ranking process options according to their long term environmental consequences.

67. In carrying out the assessment it might be beneficial to break down the calculation into a number of stages so that the relative contribution of different substances to the pollutant burden in different media and the environment as a whole can be identified.

Figure 5.2 Assessment of the Relative Magnitude of a Single Release (Sulphur Dioxide)

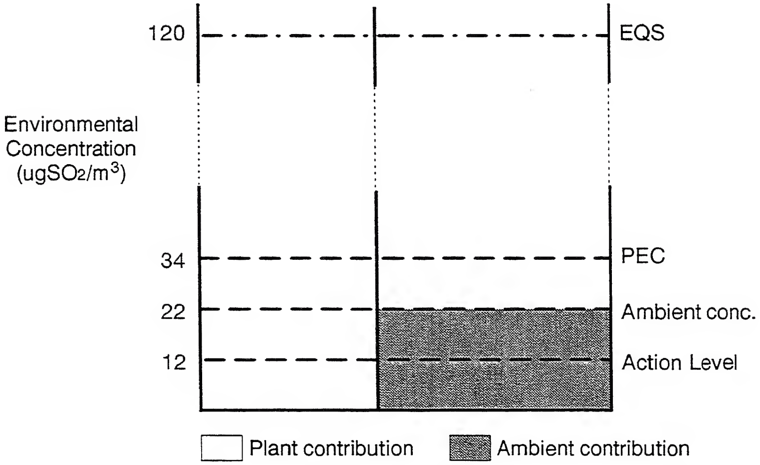
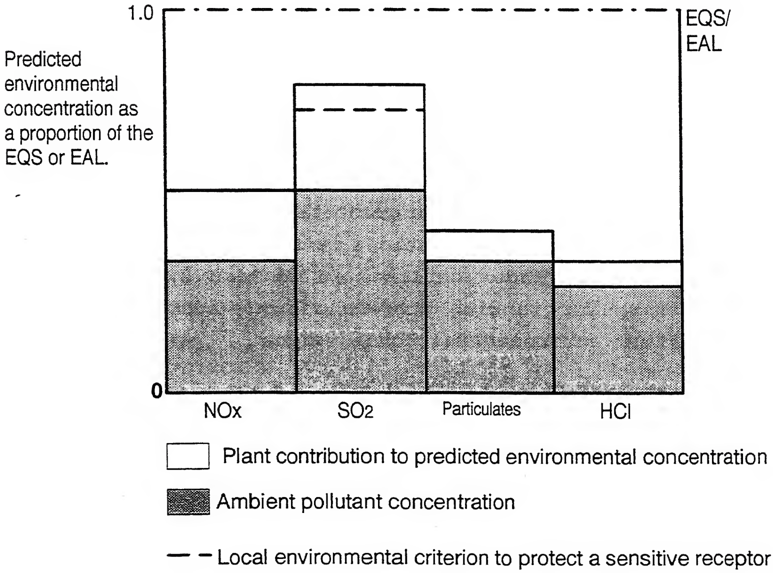


Figure 5.3 Comparison of Releases to a Single Medium (air)



68. For example, Environmental Quotients can be calculated for individual substances (Equation 1), specific media (Equation 2) and for the environment as a whole (Equation 3)

$$\textit{Environmental Quotient}_{(Substance)} = \frac{\textit{Plant contribution}}{\textit{EQS or EAL}} \quad ...(1)$$

$$\textit{Environmental Quotient}_{(Medium)} = EQ_{(a)} + EQ_{(b)} \ldots + EQ_{(i)} \quad ...(2)$$

Where a...i are substances released to a particular medium.

$$\textit{Integrated Environmental index}_{(Option)} = EQ_{(Air)} + EQ_{(Water)} + EQ_{(Land)} \quad ...(3)$$

69. The Integrated Environmental Index (IEI) for each process option should be used to prepare a ranking of options to identify the Best Practicable Environmental Option. However, the ranking may be modified by other environmental factors, such as those outlined in the following sections.

5.3 ASSESSMENT OF SHORT TERM EFFECTS OF RELEASES

70. Different process options may lead to variations in the pattern of releases, for example, a process operated intermittently may give lower annual concentrations compared to one run continuously but an increased frequency of short term peaks may be the result. The assessment of short term releases should therefore be an integral part of the environmental assessment under IPC for both new and existing processes.

71. Detailed assessment of short term effects is often complex as the maximum process contribution and maximum ambient concentration may be separated both temporally and spatially. Information on the temporal distribution of ambient pollutant concentrations and environmental parameters will be required but may be unavailable for a particular location. Moreover, for many substances, environmental criteria against which releases can be compared are absent, particularly for water and land. However, for releases to air a number of EC or WHO guidelines and odour thresholds are available. Further guidance on these values will be produced by HMIP.

72. To reduce the need for potentially extensive modelling the following screening procedure is proposed which will enable those releases likely to give rise to adverse short term effects to be identified i.e.

i) To represent an extreme worst case, the value of the maximum process contribution and maximum ambient concentration should be summed and compared with an appropriate environmental criterion. If the short term PEC is less than the environmental criterion then the release can be considered tolerable and unlikely to give rise to adverse short term effects.

ii) If the result of (i) exceeds the adopted criterion then a more detailed modelling programme should be undertaken by the operator to identify the likely frequency and magnitude of any short term effects.

73. In following the screening procedure the peak process contribution should be identified. This may occur during periods of start up and shut down, as a result of expected but unplanned releases or under particular environmental conditions.

74. The detailed assessment of short term effects should consider the temporal pattern and magnitude of releases as well as the range of dispersion conditions. The integration of these effects is likely to require detailed computer modelling. Where this is not practical, for example, due to lack of key data, it may be possible to obtain a rough estimate by adding the maximum process contribution to the long term average ambient concentration. This value can then be compared with the adopted short term criterion.

75. For existing plant the short term effects of releases should already have been considered under previous regulatory regimes. As a result, the selection and operation of new techniques may be constrained by factors such as existing stack height, location and design of outfalls or planning requirements. However, for new processes, consideration of the short term effects of releases will be an integral part of the analysis of BATNEEC/BPEO options.

76. If the results of the more detailed assessment indicate that short term releases from one or more process options will lead to adverse effects then the operator should examine the proposed technique(s). Where significant short term effects are identified these should be carried forward in the assessment and taken into consideration in ranking process options and in determining the Best Environmental Option.

5.4 ASSESSMENT OF GLOBAL WARMING POTENTIAL (GWP) OF RELEASES.

77. The release of carbon dioxide, water vapour, chlorofluorocarbons (CFCs), methane and nitrous oxide may lead to global warming. In addition, tropospheric ozone (ie in the bottom 8-16 km of the atmosphere) also acts as

a greenhouse gas but the magnitude of this effect is still under investigation.

78. It is important that the release of these gases is minimised wherever possible. Due to the nature of the effects arising from these pollutants it is not possible to incorporate them directly in the Environmental Index proposed in Section 2.4.2. Instead, process options should be ranked according to their potential to contribute to radiative forcing (global warming) expressed in carbon dioxide equivalents. The direct global warming potential (ie the warming contribution of each gas relative to an equal weight of CO_2 over a period of 100 years) of each gas are shown in Table 5.1. The total global warming potential for a particular process option may be represented by equation (4);

$$\text{Global Warming Potential}_{(Total)} = \sum_{i=1}^{n} GWP_i \times Mass_i \quad ...(4)$$

Where; Global Warming Potential$_{(Total)}$ = The weighed sum of the global warming potentials for the substances released from the process option being considered.

GWP_i = global warming potential for substance i of n released from the process option.

$Mass_i$ = Mass of substance i released from process option.

79. Some of these greenhouse gases also exert indirect radiative effects through their interaction with atmospheric chemical processes. The magnitude of these effects is currently uncertain but the final column of Table 5.1 indicates the direction of these effects.

Table 5.1 Direct Global Warming Potential for greenhouse gases.

Gas	Direct Global Warming Potential[1] (GWP)	Sign of the indirect component of the GWP
Carbon dioxide	1	None
Methane	11	Positive
Nitrous oxide	270	Uncertain
CFC 11	3400	Negative
CFC 12	7100	Negative
HCFC-22	1600	Negative
HFC-134a	1200	None

(1) Relative to an equal weight of carbon dioxide over 100 years.

5.5 ASSESSMENT OF THE POTENTIAL FOR OZONE GENERATION

80. Ozone is a highly reactive pollutant which may exert a number of damaging effects on human health, vegetation and materials. The production of ozone in the troposphere (ie the bottom 8-13km of the atmosphere) involves the action of sunlight on hydrocarbons, usually referred to as volatile organic compounds (VOCs)) and oxides of nitrogen (NO_x). The availability of NO_x downwind of a source controls the spatial extent of the area within which raised ozone concentrations may be generated. Within this area the magnitude and distribution of the pollutant is controlled by the occurrence and characteristics of the available hydrocarbons (Derwent and Jenkin, 1991).

81. There is a large variation between the importance of individual VOCs in their potential for ozone generation, depending on their reactivity with hydroxyl (OH) radicals and the subsequent production of peroxy (RO_2) radicals. In order to assess the relative effect of different hydrocarbons in the episodic production of ozone and provide a basis for their control the UNECE VOC convention (UNECE 1991) has proposed the concept of the Photochemical Ozone Creation Potential (POCP). The POCP is defined as the change in photochemical ozone production due to a change in emission of that particular VOC. The POCP may be determined by photochemical model calculations or by laboratory experiments.

82. Estimated individual POCP values will vary both temporally and spatially depending on the VOC composition of the modelled air parcel, the assumed meteorological conditions and NO_x concentrations. However, although there is considerable uncertainty over individual POCP values the approach can be used to classify VOC species according to their importance in ozone production and average values assigned to each class of compound. Table 5.2 shows the classification and average POCP value for a range of different compounds.

Table 5.2 Classification and average photochemical ozone creation potential for volatile organic carbon compounds.

Relative importance[1]	Substance group	Substances included/ excluded	Average POCP value[2]
More important	Alkenes		91
	Aromatics	Except benzene	81
	Alkanes	≥ C6 alkanes except 2,3 dimethylpentane	45
	Aldehydes	All aldehydes except benzaldehyde	57
	Biogenics	Isoprene	–
Less important	Alkanes	C3–C5 alkanes and 2,3 dimethyl pentane	37
	ketones	Methyl ethyl ketone and methyl t-butyl ketone	53
	Alcohols	Ethanol	27
	Esters	All esters except methyl acetate	27
Least important	Alkenes	Ethane	8
	Alkynes	Acetylene	17
	Aromatics	Benzene	19
	Aldehydes	Benzaldehyde	–33
	Ketones	Acetone	18
	Alcohols	Methanol	12
	Esters	Methyl acetate	2.5
	Chlorinated hydrocarbons	Methyl chloroform, methylene chloride, trichloroethylene, tetrachloroethylene	2

(1) From UNECE (1991), VOC Convention Annex IV, Table 1.

(2) Calculated from individual substance values given by Derwent and Jenkin (1991), Table 4.

83. The POCP values shown in Table 5.2 can be used either as a basis for identifying less damaging substitutes for substances used in a process or to assess the relative ozone generating potential of different process options. When seeking to identify substitute compounds for those of a relatively high POCP value it is important that the properties of the proposed alternative are carefully considered. For example, although both benzene and methyl chloroform have low POCP values, benzene is a known carcinogen and methyl chloroform is relatively long lived and may persist into the stratosphere where it contributes to stratospheric ozone depletion.

84. When considering the POCP of different process options the total POCP of a particular process can be represented by;

$$POCP_{(total)} = \sum_{i=1}^{n} POCP_i \times Mass_i \quad ...(5)$$

Where; $POCP_{(Total)}$= the weighed sum of all potential ozone generating substances released from the process concerned.

$POCP_i$ = the POCP for substance i of n substances released from the process.

$Mass_i$ = the annual mass of substance i released from the process.

5.6 ASSESSMENT OF WASTE ARISINGS

85. Many processes will generate quantities of solid or liquid waste, ie material which is not released to air or water. These wastes may be treated or disposed of on-site or removed from the plant for treatment or disposal elsewhere.

86. Incorporating such waste arisings into the calculation of an Integrated Environmental Index is less straightforward than is the case with releases to air or water. This is because their environmental effects are likely to depend on a range of more complex interactions . A separate means of comparing this aspect of different process options is required, and this can be achieved by assessing each waste arising on the basis of quantity and relative hazard potential. The relative hazard potential will be determined by its physical, chemical and biological characteristics.

87. A number of hazard assessment schemes can be found in the literature. The one proposed in this document is based on that developed by the UK Government-Industry Working Group on Priority Setting and Risk Assessment (DoE 1991).

88. The scheme is based on a number of parameters:

(i) toxicity (to mammals and aquatic organisms);

(ii) potential for bioaccumulation;

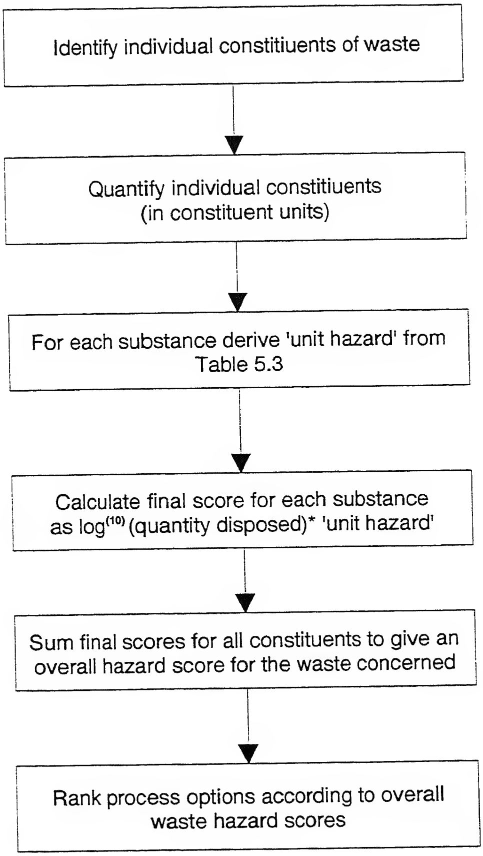
(iii) degradation (in soil/water); and

(iv) other physical characteristics such as solubility, adsorption potential and volatility.

89. Each of these parameters is scored and a total score is obtained by multiplying the individual scores. The score

obtained represents the potential hazard for a unit quantity of the substance concerned. The 'unit hazard' can then be weighed by the quantity generated to obtain a final score for the substance concerned. The final scores for all the components of a waste can then be summed to give an overall hazard score for the process being considered. Different process options producing different wastes can then be ranked according to their overall hazard scores. This process is summarised in Figure 5.4. The waste with the lowest overall score could be considered the most environmentally tolerable.

Figure 5.4 Procedure for Ranking Different Process Options with Regard to Waste Arisings


Identify individual constitiuents of waste
Quantify individual constitiuents (in constituent units)
For each substance derive 'unit hazard' from Table 5.3
Calculate final score for each substance as log(10) (quantity disposed)* 'unit hazard'
Sum final scores for all constituents to give an overall hazard score for the waste concerned
Rank process options according to overall waste hazard scores

90. A more detailed description of the hazard assessment scheme is provided in Annex B, together with a table (Table B1) showing the exposure, toxicity and unit hazard scores for a range of substances. Table 5.3 summarises the unit hazard scores for the substances considered. The final hazard score for the process considered is given by equation (6).

$$\textit{Final hazard score} = \mathrm{Log}_{10}(\textit{Quantity for disposal}_i) \times \textit{Unit hazard score}_i \qquad \ldots(6)$$

Where; Final hazard score = Weighted sum of the unit hazard scores for all substances arising from the process option considered.

Unit hazard score$_i$ = the unit hazard score given in Table 5.3 for substance i of n arising.

Quantity for disposal$_i$ = the quantity of substance i arising from the process option being considered.

91. It should be noted, however, that no absolute quantitative meaning should be applied to these scores, all that can be inferred from them is that a waste with an overall hazard score of (say) 250 is likely to represent less of a hazard than one with a score of 350. This information can, along with the IEI and other factors, be taken into account in reaching a judgement on the process/abatement option which represents the Best Environmental Option, and in ranking each practicable option considered in the assessment.

Table 5.3 Example Unit Hazard Scores for some inorganic and organic substances.

Substance	Unit hazard score
Cadmium	1533
Nickel	1210
Vinyl chloride	976
Benzene	504
Mercury	504
Acrylo-nitrile	433
Formaldehyde	425
Chromium	693
Dichloro-methane	252
Ethyl benzene	216.4
1,3 Butadiene	186.4
Methyl ethyl ketone	127
Styrene	80.4
Xylene	27.6
Toluene	18.8

92. Pending the outcome of the consultation exercise, unit hazard scores have only been derived for a limited number of substances to illustrate the operation of the procedure. In the interim, Inspectors requiring further guidance on the unit hazards to be applied to substances not on the list should contact the relevant section in HMIP headquarters.

5.7 OTHER ENVIRONMENTAL FACTORS

93. The factors outlined above as being relevant to ranking process options are neither exhaustive nor exclusive. Other or additional factors might be pertinent to any particular process at a specific location. For instance, if authorised a release might give rise to a Predicted Environmental Concentration close to an Environmental Quality Standard (or Environmental Assessment Level). Greater care will need to be taken in sanctioning such releases. As a rule of thumb, this might be invoked if the Environmental Quotient for the release is greater than 0.8.

5.8 IDENTIFICATION OF BEST ENVIRONMENTAL OPTION

94 The results of the environmental assessments of the process or abatement options generated using the procedure should be used to rank the options and identify the Best Environmental Option (BEO). It should be noted that, at this stage, the objective is to select the process or abatement option which provides the greatest protection or benefit to the environment as a whole; the only economic consideration is that the options should be viable. The costs of the selected option are considered at the next stage in the procedure.

94. In view of the difficulties inherent in making direct comparisons between different types of environmental effects, for example, direct toxic effects and global warming potentials, the selection of the BEO must be a matter of professional judgement, weighing all factors considered in the assessment. However, the results of the environmental assessment and the justification for the final selection of the BEO must be clearly presented so that inspectors and others are readily able to review and audit the proposals.

95. In presenting the results of the assessment it may be helpful to set out the different environmental considerations as shown in Table 5.4. The relative importance attached to each of the environmental factors in selecting the BEO should also be clearly stated. In most cases it would be expected that the greatest weight would be attached to the Environmental Index and that the option with the lowest index would represent the BEO. The relative importance of the BEO rests in its function as a measure of the direct long term effects of the process across all three media on a site specific basis. However, other environmental factors are significant, the choice of the BEO may be modified.

96. Table 5.4 provides an example of how the final results might be presented. The process options have been ranked in descending order of Integrated Environmental Index. Although Option 4 might initially be considered the BEO as a result of possessing the lowest index value (IEI = 0.5) this represents only a small improvement over Option 3 (IEI = 0.6). Consideration of the relative performance of these two options with regard to other environmental factors indicates that Option 3 produces potentially lower effects for waste disposal and ozone generation potential. Option 3 might, therefore, be considered to represent the BEO for the process being considered.

97. The net result of Stage II should be a clear report outlining the assessments carried out on the options generated under Stage I. This should fully justify the final ranking of the options and the choice of best environmental option for the site in question.

Table 5.4 Selection of the Best Environmental Option

Process option	Environmental Index	Adverse Short Term Effects	Greenhouse Potential (CO_2 equiv. kt.yr-1)	Ozone Generation Potential	Waste hazard potential	Other Factors eg PEC (1) >0.8* EQS or EAL	Rank order for BEO
Base case	5	SO_2: 40hrs > WHO 1 hr limit	20	1000	4500	SO_2/NO_x	5
Option 1	3	None	17	500	3250	SO_2	4
Option 2	2	None	15	500	3000	NO_x	3
Option 3	0.6	None	10	50	500	—	1
Option 4	0.5	SO_2: 10hrs > WHO 1 hr limit	12	300	2000	SO_2	2

(1) Predicted Environmental Concentration (Plant contribution + ambient concentration).

6.0 STAGE III: DETERMINATION OF SITE SPECIFIC BPEO OPTION

6.1 SELECTION OF SITE SPECIFIC BPEO

98. The proposed procedure for selecting the site specific BPEO is illustrated in Figure 6.1 The overriding principle in determining the BPEO is: if the operator's preferred process/abatement option corresponds to the Best Environmental Option then no further justification is required. However, if some other option is proposed by the operator, this must be properly justified, particularly where the grounds are the avoidance of excessive cost. Guidance on the economic assessment of process or abatement options is given in the following section, supplemented by Annex C.

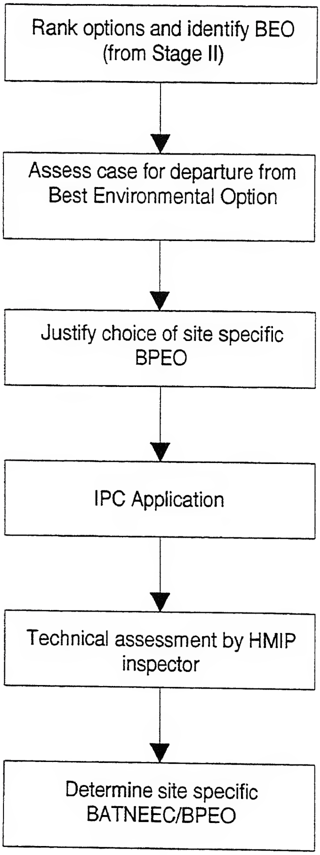
6.2 JUSTIFICATION OF OPERATOR'S PREFERRED OPTION

99. Operators should reach their own view as to which of the potential process/abatement options constitutes the site-specific BATNEEC/BPEO by considering the cost-effectiveness of options in terms of pollution reduction or prevention. The application of cost-effectiveness analysis assists the operator in two ways:

i) Options that are cost-effective can be identified. A cost-effective BPEO process/abatement option is defined as the one which achieves a given level of pollution control at least cost;

ii) The costs of achieving more stringent levels of pollution control can be shown. This information will illustrate any significant 'break point' beyond which reductions in pollution can only be achieved at much greater incremental cost.

Figure 6.1 Determining the Site Specific BPEO



PROCEDURE	COMMENTS
Rank options and identify BEO (from Stage II)	If the Best Environmental Option identified in Stage II is proposed then no cost assessment is required.
Assess case for departure from Best Environmental Option	If the BEO is considered too costly then cost assessment required. Cost options to give annualised and incremental costs.
Justify choice of site specific BPEO	Synthesize all information to justify final choice of site specific BPEO.
IPC Application	Operator submits IPC application with BPEO evaluation to HMIP.
Technical assessment by HMIP inspector	HMIP inspector reviews application and audits operator's justification of BPEO.
Determine site specific BATNEEC/BPEO	HMIP determine IPC application.

100. When identifying the least cost option, it is important to note that the cost-effectiveness result may be sensitive to the context in which an individual abatement technique is applied. For example, plant is designed for a specified range of operating conditions, and to operate beyond that range or under different conditions may entail additional operating and/or capital costs.

101. In identifying a 'break-point' where the costs of further reductions in pollution potential start to rise significantly, it is important to have a quantitative measure of the environmental consequences of the releases involved. Where the choice of the preferred option has been based largely on the long term consequences of the releases as indicated by the Environmental Index, then this may provide a convenient measure of the overall pollution potential of a process. However, as outlined in section 5.8, when the preferred option has been selected on the basis of other environmental factors, it may be more appropriate to use different measures of pollution potential such as the quantity of individual substances removed or the global warming potential of different abatement options. The ranking of options derived under stage II should provide the basis for this. Again the assumptions made should be fully justified and clearly presented in the application.

102. Two main techniques can be used to identify cost-effective treatment or abatement options:

i) Annualized costs of different levels of pollution control can be plotted on a diagram, as illustrated in Figure 6.2; or

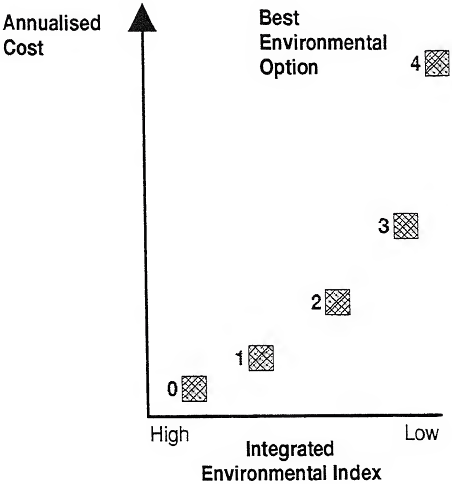
ii) Incremental cost-effectiveness can be presented arithmetically to compare the costs and abatement of a process option with those of the next more environmentally harmful option, as shown in Table 6.1. This can be expressed more formally as:

$$Incremental\ Cost = \frac{\begin{matrix}Cost\\Option\ (1)\end{matrix} - \begin{matrix}Cost\\Option\ (2)\end{matrix}}{\begin{matrix}Difference\ in\ pollution\\potential\ (Option\ 2 - Option\ 1)\end{matrix}} \quad ...(7)$$

103. Figure 6.2 shows the costs and environmental effects for a range of different process options/techniques, 0 to 4, for a hypothetical process. An environmental index derived from the Stage II environmental assessment is shown for each option, including the current operation which is shown as the base case. The operator might consider Option 3 as representing the site-specific BPEO even though Option 4 has a better BPEO index value, on the basis of the higher incremental cost entailed at that site in attaining the environmental benefit of Option 4.

104. Table 6.1 is an example of how the incremental costs of pollution control can be presented. Other things being equal, in this case it might be concluded that the site-specific BATNEEC is option 3, because of the doubling of incremental cost to achieve any greater improvement.

Figure 6.2 Principles for Establishing the Site Specific BPEO Option



Note:
- * Options 0-4 generated under Stage I and evaluated and ranked under Stage II.
- * Integrated Environmental Index, modified as appropriate by other environmental factors.

Table 6.1 Illustration of the Incremental Cost of Pollution Control

Option	Equivalent Annual Cost	Incremental Improvement in IE Index	Incremental Cost
Base case (uncontrolled)	£0	–	–
Option 1	£20,000	1	£20,000
Option 2	£50,000	1	£30,000
Option 3	£100,000	1	£50,000
Option 4	£200,000	0.5	£100,000

105. Correctly identifying the base case and the assumptions on which it is defined are important considerations in addressing the costs. When considering an existing process, previously-incurred costs of environmental protection and pollutant abatement systems should be included in the base case, and must not be added to any of the potential process/abatement options. It is only the incremental costs of installing and operating additional techniques that are relevant for cost-effectiveness analysis.

106. The outcome of Stage III should be the selection, with written justification, of the Best Practicable Environmental Option for operating the process on a particular site. In most cases this should also represent the Best Available Technique Not Entailing Excessive Cost, however, other modifying factors, such as operator competence, may be considered by the Inspectorate in finally determining an application.

107. It should be emphasised that the procedure outlined in this note should not be used in a mechanistic way. The final justification of the BPEO should weigh all relevant factors based on expert judgement: first on the part of the operator in compiling an application and second by the site inspector in determining an application. If used in a common sense non mechanistic fashion, the procedure provides the means for doing this in a clear, and fully auditable way.

7.0 REFERENCES

Derwent RG and Jenkin ME (1991). Hydrocarbons and the Long Range Transport of Ozone and PAN across Europe. Atmospheric Environment, 25A (8), 1661-1678.

HMSO (1988). Best Practicable Environmental Option. 12th Report of the Royal Commission on Environmental Pollution. Cmnd 310. HMSO, London.

HMSO (1989) Water and the Environment. The implementation of European Community directives on pollution caused by certain dangerous substances discharged into the aquatic environment. Department of the Environment Circular 7/89, Welsh Office Circular 16/89. HMSO, London.

HMSO (1993) Guidelines on Discharge Stack Heights for Polluting Emissions. Technical Guidance Note (Dispersion) D1. HMSO, London.

UNECE (1991). Protocol to the 1979 convention on long-range transboundary air pollution concerning the control of emissions of organic compounds or their transboundary fluxes. United Nations Economic Commission for Europe, Geneva.

ANNEX A ENVIRONMENTAL QUALITY STANDARDS AND HMIP ENVIRONMENTAL ASSESSMENT LEVELS

A1.0 INTRODUCTION

108. In previous sections of this report the basis for assessing the tolerability of a single release and determining the relative environmental consequences of different process options, have been set out.

109. The approach adopted requires that for each substance three criteria are defined against which the predicted environmental concentration arising from the release can be assessed i.e.

i) a concentration above which unacceptable or 'intolerable' environmental effects may occur as a result of long term exposure to a pollutant;

ii) a concentration below which further assessment of the environmental consequences of a release is not considered necessary as any effects are likely to be absent or can be considered insignificant with present knowledge;

iii) a concentration above which adverse effects to a particular pollution receptor may arise as the result of short term exposure to a pollutant.

110. Ideally, these criteria would be derived in a consistent manner to provide a similar measure of protection to receptors in different media.

111. The selection of concentrations to represent these criteria needs to be given careful consideration. In determining an application under IPC, section 7(2) of EPA 90 requires HMIP to ensure that releases do not lead to a breach of any prescribed environmental quality standard (EQS). Since many EQSs are expressed as annual averages they can be considered to provide protection against long term exposure to the pollutant. Moreover, as they have been developed through a process involving consultation they can be considered, at least in part, as representing society's willingness to tolerate a certain level of pollution. EQSs, therefore, provide suitable criteria against which the tolerability of release can be assessed (ie criteria (i) above).

112. However, for many substances EQSs have not been defined. For substances where the necessary criteria are absent, HMIP has developed suitable interim values based on existing published information. In the longer term it is intended to refine the assessment criteria through HMIP's research programme.

113. This annex provides guidance to HMIP Inspectors on the availability of EQSs for different media and other criteria which have been developed by HMIP for use in the assessment procedure.

A2.0 ENVIRONMENTAL QUALITY STANDARDS

114. An environmental quality standard (EQS) can be defined as the concentration of a substance in the receiving environment which must not be exceeded if the environment is to be suitable for a particular purpose or use, or to achieve a given level of protection for a particular receptor(s). In the context of this report the term EQS

Table A2.1 EC Mandatory Environmental Quality Standards for Air Pollutants

SUBSTANCE	**Reference Period**	**Calculated from:**	**Limit value ($\mu g/m^3$)**	**Associated Value for Suspended Particulates (1) ($\mu g/m^3$)**
Sulphur Dioxide (Directive 80/779/EEC)	Year	Median of daily means	80 120	> 40 ≤ 40
	Winter 1 Oct - 31 Mar	Median of daily means	130 180	> 60 ≤ 60
	Year	98% tile of daily (24hr) means	250) not to be) exceeded 350) on >3 days	> 150 ≤ 150
Suspended Particulates(1) (Dir. 80/779/EEC)	Year	Median of daily means	80 (150 - Gravimetric)	
	Winter 1 Oct - 31 Mar)	Median of daily means	130	
	Year	98% tile of daily (24hr) means	250	
		(95% tile - Gravimetric)	(300 - Gravimetric)	
Nitrogen Dioxide (Dir. 85/203/EEC)	Calendar Year	98th% tile from mean values per hour or lesser period	200	
Lead (Atmospheric particulate) (Dir. 82/884/EEC)	Year	Annual mean	2	

(1) **Measured by black smoke method**

has been applied only to limits prescribed by the Secretary of State either through appropriate regulations or direction to the relevant competent authority. Where different uses for a medium spatially overlap, more than one EQS may apply, under these circumstances the most stringent must be used.

115. Relevant EQSs for Air are shown in Table A2.1 and for Water in Table A3.3. There are currently no EQSs relating to the release of substances direct to land.

A3.0 HMIP ENVIRONMENTAL ASSESSMENT LEVELS (EALS) FOR LONG TERM EXPOSURE

A3.1 INTRODUCTION

116. The approach to environmental assessment set out in the main body of this report requires the availability of environmental criteria against which long and short term exposure to pollutants can be assessed. This section considers the derivation of environmental criteria for long term exposure to releases. Where EQSs exist based on long term average data then these should be used to assess the tolerability of releases. However, for substances for which no EQS is available guidance on the criteria to be applied is required.

117. In developing long term environmental assessment levels (EALs) three objectives need to be considered;

i) the protection of human health;

ii) the general protection of ecosystems; and

iii) the protection of other sensitive receptors such as buildings or commercial activities (eg fish farms) requiring a particular environmental quality.

118. Ideally, EALs to fulfil these objectives would be defined for each pollutant based on the sensitivity of a particular habitats or receptors, be produced according to a standardised protocol to ensure that they are consistent, reproducible and readily understood and provide similar measures of protection for different receptors, both within and between media. In addition, EALs should take into consideration habitat specific environmental factors such as pH or nutrient status, bioaccumulation, transfer and transformation processes where necessary.

119. A suite of EALs which have been derived in this consistent manner are not currently available but it is intended to develop guidance in this area as part of HMIP's future research programme. In the interim, provisional EALs based primarily on human health criteria have been derived from a number of United Kingdom and international sources.

120. The sources of data used in developing the provisional environmental assessment levels are summarised in Table A3.1 and discussed in more detail in succeeding sections. For air and water, values were selected from these sources in descending order of precedence. For example, for air, if no WHO guideline where available information from other international sources would be sought and so on. In the case of land, EALs were based on the most stringent criteria from the sources quoted.

Table A3.1 Summary of data sources used for setting provisional Environmental Assessment Levels.

AIR	WATER	LAND (via deposition from air)
No EQS available	No EQS available	No EQSs available
WHO Air Quality Guidelines for Europe 1987. (As annual mean or risk)	Proposed EQS (eg those proposed for SWQOs)	Internationally agreed critical loads or levels for Sulphur and Nitrogen
Other international organisations	NRA/DoE river classification or operational guidelines.	Sludge code of practice
Relevant National organisations (eg US EPA IRIS database)	Relevant National organisations. (eg US EPA)	Contaminated land action values
HSE Occupational exposure standard (OES/400)	Expert judgement only[5]	MAFF
HSE Maximum exposure limit (MEL/4000)		International organisations
Expert judgement only[5]		Relevant National organisations
		Expert judgement only[5]

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[5] Not necessary to use expert judgement only in setting EALs

A3.2 DERIVATION OF PROVISIONAL ENVIRONMENTAL ASSESSMENT LEVELS FOR LONG TERM EXPOSURE TO AIR.

121. Table A3.1 shows the sources of data from which provisional environmental assessment levels have been derived. Although the WHO Air Quality Guidelines (1987) contain values for some 27 substances only a limited number are expressed as annual average or risk based values suitable for use as long term EALs. For substances where the WHO guideline is given as a unit risk for exposure to 1 ug/m^3, EALs have been estimated based on a lifetime risk of $1*10^{-6}$. Similarly for risk based values extracted from the US EPA IRIS database a criterion of $1*10^{-6}$ has been adopted.

122. If no other published information is available then EALs have been derived from Health and Safety Executive occupational exposure limits. Values given in EH40/93 (HSE 1993) have been used to produce the values in Table A3.2. Where the substance is listed in Table 2 of EH/40 (Occupational Exposure standards) the tabulated 8hr TWA (Time Weighted Average) value has been divided by 400 to produce the EAL. If the substance is listed in Table 1 of EH40/93 (Maximum Exposure Limit) with an 8hr TWA value then a divisor of 4000 has been applied.

123. Great care is needed in deriving ambient air quality criteria from occupational standards, hence the position of this source of information in the order of preference given in Table A3.1. The practice of using occupational standard in assessing chimney height has been well established within HMIP and its predecessor bodies. [See for example, Mahler (1967), Ireland (1970), or more recently HMSO (1993).] These applications usually entail the comparison of predicted short term (3 minute) concentrations with one fortieth of the relevant occupational standard. The divisor being to allow for the assumed lesser resistance of more sensitive members of the community and the difference

between occupational and residential exposure times (Mahler 1967).

124 This practical approach does not take into account any additional ecological effects which may arise as a result of long term exposure. Consequently, a further safety factor of 10 has been applied to the value of 40 commonly used for chimney height determination. This results in an annual average EAL being calculated as 1/400 of the occupational exposure standard. An additional safety factor of 10 has been applied to substances which have been allocated Maximum Exposure Limits (Table 1, HSE 1993), to take account of the differences between setting these standards and those listed in Table 2 (OES) of HSE (1993). Occupational Exposure Standards (Table 2, HSE 1993) can be considered as No Observed Adverse Effect Levels, whereas Maximum Exposure Limits (Table 1, HSE 1993) are assigned to those substances for which either there is no threshold of effect or control to occupational exposure standard is not practicable. (HSE 1993).

125 The interim long term environmental assessment levels derived from this approach are given in Table A3.2.

A3.3 DERIVATION OF PROVISIONAL ENVIRONMENTAL ASSESSMENT LEVELS FOR LONG TERM EXPOSURE TO WATER.

126 Table A3.3 sets out the Environmental Quality Standards and Assessment Levels for releases to water. The data presented in Table A3.3 is of necessity somewhat complex due to the manner in which EQSs have been set and care should be taken in the use of this data. In selecting an EQS or EAL from this table the user should first consider the use or type of the receiving water, ie whether water is abstracted or is a designated salmon or cyprinid fishery. If an EQS is available then this should be applied.

126 Where the water does not have a designated use then the Environmental Assessment Level should be applied (final column in Table A3.3). Under these circumstances the EAL selected should be based on the EQS which provides the most appropriate protection to the reach concerned. It should be remembered that the EAL is intended to provide guidance to Inspectors on the maximum tolerable level of a substance in water and therefore even where the EAL is clearly based on an EQS, care should be taken in its application to non-designated waters. Where different requirements apply to a particular stretch of water the most stringent should be used.

127 Apart from mercury there are no set standards for the concentration of pollutants in biota. Table 3.4 provides guidance on the EQS for mercury in fish and on typical levels of some other substances in biota.

A3.4 DERIVATION OF PROVISIONAL ENVIRONMENTAL ASSESSMENT LEVELS ARISING FROM THE DEPOSITION POLLUTANTS TO LAND.

128 There are no generally applicable environmental quality standards available for soils, although specific values have been produced for the disposal of sewage sludge to agricultural land. Setting quality standards directly for soil would be a complex process likely to involve consideration of a number of factors including soil type, potential land use and underlying geology. To overcome these problems a pragmatic approach to limit the rate of application of pollutants to the soil has been developed and consequently soil EALs have been expressed as a maximum deposition rate (MDR).

129 The maximum deposition rate is the quantity of pollutant which can be added to the soil daily over a 100 year period before the selected soil quality criterion is exceeded.

Before calculating the MDR the soil quality criterion was first corrected for the median ambient soil pollutant concentration. To maintain consistency with the derivation of EALs for other media no allowance has been made for degradation or other removal processes in the soil. Therefore, for some readily degradable substances the provisional MDR will be a significant underestimate of the true value and allowance may need to be made for this on a site and pollutant specific basis. A soil mixing depth of 7.5 cm and soil density of 1000kg/m^3 has been assumed for the purposes of calculating the MDR.

130 The provisional MDR is given by;

$$MDR = \frac{(SQC - AMB_s) * D_s * d_s}{T}$$

Where MDR provisional maximum deposition rate (mg/m^2/day);

SQC is the selected soil quality criteria (mg/kg dry soil);

AMB$_s$ is the median soil pollutant concentration;

D$_s$ is the soil density (1000 kg/m^3); and

d$_s$ is the mixing depth for the pollutant concerned (7.5 cm).

131 Ambient soil metal concentrations have been derived from Davis (1980) and McGraph and Loveland (1992). Representative data for ambient concentrations of organic pollutants in UK soils have been taken from a variety of sources.

132 The provisional environmental assessment levels for soils (expressed as a deposition rate) are given in Table A3.5, together with the soil quality criteria applied in their derivation.

A4.0 DERIVATION OF EALS FOR SHORT TERM EXPOSURE TO AIR

133 The Environmental Assessment Levels for short term exposure (see Section 5.5) to air borne pollutants have been derived from a similar hierarchy of sources to that described in Section A3.1. Where available, EQSs have been adopted, but where such values were not available other sources have been used, as shown in Table A4.1.

Table A4.1 Summary of data sources used for setting provisional Environmental Assessment Levels for short term exposure to air pollutants.

Source of value	Applied safety factor (Raw value/safety factor)
Environmental Quality Standard	None
WHO Air Quality Guidelines for Europe 1987.	None
HSE Occupational Exposure, Short Term Exposure limit (10 minute reference period)	100
HSE Occupational Exposure, Long Term Exposure Limit (8 hr TWA reference period)	33.3(1)
HSE Maximum Exposure Limit, Short Term Exposure Limit (10 minute reference period)	1000
HSE Maximum Exposure Limit, Long Term Exposure Limit (8hr TWA reference period)	333(6)

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[6] Where no Short Term Exposure Limit was available a value 3 times the Long Term 8hr TWA has been used (HSE 1993) giving an overall safety factor of (100/3) i.e. 33.3 in the case of values based on OESs and 333 in the case of assessment levels based on MELs.

134 The Environmental Assessment Levels for short term exposure to air pollutants are given in Table A4.2. From Table A4.2 it can be seen that the reference period for the EALs varies between substances. This variation may be related to the minimum period required to collect a representative sample of air for the substance concerned, or in some cases, the duration of exposure from which the assessment level has been derived. It is recognised that in some cases the models used to predict the plant contribution will be unable to calculate values for the required reference period. Therefore, it may be necessary to convert values calculated for one reference period to another for which an EAL is available. Table A4.3 indicates some approximate conversion factors which may be used for this purpose.

Table A4.3 Relationship between different sample averaging times from an elevated source

Sample Reference Period	Approximate ratio to 1 hour reference period
3 minute	3
30 minute	1.5
1 hour	1
8 hour	0.25
24 hour	0.2

135 It should be clearly understood that these values apply to estimated concentrations downwind of a single elevated source. For ambient air quality where there are widespread sources of emission, different relationships will exist. These ratios will also depend on the relative stability of the atmosphere at the time of the release. Under unstable conditions (Pasquill categories A and B) high

concentrations of pollutants may occur at ground level as sudden local transport of pollutants through the atmosphere may take place. Under stable conditions (Pasquill categories F and G) atmospheric stratification and the overall lower turbulence will tend to reduce fluctuations in predicted ground level concentrations.

A5.0 DERIVATION OF 'ACTION LEVELS' FOR LONG TERM EXPOSURE TO POLLUTANTS.

136 Where the Predicted Environmental Concentration (PEC), (ambient pollutant concentration + plant contribution) is very low the environmental consequences of the release can be considered negligible. Under these circumstances there is little to be gained from a detailed assessment of the environmental consequences of the release. However, above this level significant environmental effects may occur and more detailed assessment, possibly leading to regulatory action can be justified.

137 Ideally, the definition of this action level would be based on an understanding of the 'true' no observed effect level for the pollutant. However, there is insufficient information for this to be achieved at present. In the interim, provisional Action Levels have been set as a specified fraction of the EAL as outlined in Table A5.1.

Table A5.1. Derivation of provisional Action Levels

AIR	WATER	LAND
EQS or WHO/10	EQS/10	Critical load for most sensitive land /10.
Risk of 10^{-8} for risk based limits	EQS/10	Other sources/100
Values derived from other sources /100	Other sources/100	

A6.0 REFERENCES

Davis RD (1980) Control of contamination problems in the treatment and disposal of sewage sludge. Water Research Centre Technical Report number TR 156, Medmenham.

HMSO (1993) Guidelines on discharge stack heights for polluting emissions. Technical Guidance Note (Dispersion) D1. HMSO, London

HSE (1993) EH40/93 Occupational exposure limits 1993. HMSO, London.

Ireland FE (1970) The determination of chimney heights in Britain. One Hundred and Sixth Report on Alkali etc. works 1969. HMSO, London.

Mahler EAJ (1967) Standards of emission under the Alkali Act. One Hundred and Third Annual Report on Alkali etc. works by the Chief Inspectors. 1966. HMSO, London.

McGraph SP and Loveland PJ (1992). The soil geochemical atlas of England and Wales. Blackie Academic and Professional, London.

Table A3.2 Environmental Assessment Levels for Long Term Exposure to non metallic inorganic substances in air

INORGANIC NON-METALLIC SUBSTANCES	Environmental Assessment Level			IARC Cancer Class (1f 1 or 2A) VDP = Vegetation Damage Potential BDP = Building Damage Potential (Footnote 3)
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)	
Ammonia	EPA	Year	100	VDP
Asbestos	EPA	Year	4×10^{-6} fibres/ml	Class 1
Carbon Disulphide	WHO	24hrs	100	WHO odour 30 mins reference period $20\mu g/m^3$
Nitric Acid	HSE (O)	Year	12.5	BDP
Nitrogen Dioxide NOx	Expert judgement	Year	83.3	BDP WHO Vegetation Damage One Year reference period $30\mu g/m^3$ and 4 hrs reference period $95\mu g/m^3$
Nitrous Oxide	HSE (O)	Year	450	
Particulates	EC (Mand.)	Year	150	VDP BDP
Phosphorous	HSE (O)	Year	0.25	
Halogens/Halides:-				
Bromine	HSE (O)	Year	1.75	VDP

INORGANIC NON-METALLIC SUBSTANCES	Environmental Assessment Level			IARC Cancer Class (1f 1 or 2A) VDP = Vegetation Damage Potential BDP = Building Damage Potential (Footnote 3)
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)	
Chlorine	HSE (O)	Year	3.75	VDP
Chlorine dioxide	EPA	Year	0.2	BDP
Fluoride	HSE (O)	Year	6.5	BDP Fluorosis at $1.25\mu g/m^3$
Hydrochloric Acid	EPA	Year	7	VDP

INORGANIC METALLIC AND ORGANO-METALLIC SUBSTANCES	Environmental Assessment Level			IARC Cancer Class (1f 1 or 2A) VDP = Vegetation Damage Potential BDP = Building Damage Potential (Footnote 3)
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)	
Antimony	HSE (O)	Year	1.25	
Arsenic	WHO	Life Time	3×10^{-4}	Class 1
Barium (Sol.)	HSE (O)	Year	1.25	
Beryllium	EPA	Year	0.0004	
Boron ($B_2 0_3$)	HSE (O)	Year	25	VDP
Cadmium	WHO	Year	0.0075	(Subj. Crop uptake)
Chromium (VI)	WHO	Life Time	2.5×10^{-5}	Class 1 (Cr VI)
Cobalt	HSE (O)	Year	0.25	
Copper	HSE (O)	Year	0.5	VDP
Iron oxide (fume)	HSE (O)	Year	12.5	
Iron Salts	HSE (O)	Year	2.5	
Lead	EC (Mand.)	Year	2	
Tetraethyl lead	HSE (O)	Year	0.25	
Manganese	WHO	Year	1	

INORGANIC METALLIC AND ORGANO-METALLIC SUBSTANCES	Environmental Assessment Level			IARC Cancer Class (1f 1 or 2A) VDP = Vegetation Damage Potential BDP = Building Damage Potential (Footnote 3)
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)	
Mercury				VDP
- Inorganic	WHO	Year	1	
- Organic (meth.)	HSE (O)	Year	0.025	
Molybdenum				
- soluble	HSE (O)	Year	12.5	
- insoluble	HSE (O)	Year	25	
Nickel	WHO	Year	2.5×10^{-3}	Class 1, VDP
Platinum				
- Sol.	HSE (O)	Year	12.5	
- Salts	HSE (O)	Year	$5 ng/m^3$	
Selenium	HSE (O)	Year	0.25	
Tin				
- Inorganic	HSE (O)	Year	5	
- Organic	HSE (O)	Year	0.25	
Titanium dioxide	HSE (O)	Year	12.5	

INORGANIC METALLIC AND ORGANO-METALLIC SUBSTANCES	Environmental Assessment Level			IARC Cancer Class (1f 1 or 2A) VDP = Vegetation Damage Potential BDP = Building Damage Potential (Footnote 3)
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)	
Vanadium: Pentoxide (fume & dust)	HSE (O)	Year	0.13	
Pentoxide (tol. inhal. dust)	HSE (O)	Year	1.25	
Zinc - Zn Cl - Tot. Inhal. Dust	HSE (O) HSE (O)	Year Year	2.5 25	VDP

ORGANIC SUBSTANCES	Environmental Assessment Level			IARC Cancer Class (1f 1 or 2A) VDP = Vegetation Damage Potential BDP = Building Damage Potential (Footnote 3)
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)	
Aliphatics:				
Acetaldehyde	EPA	Year	0.5	
Acetonitrile	EPA	Year	0.01	
1,3 - Butadiene	EPA	Year	4 ng/m^3	(Cancer risk)
Ethyl Acrylate	HSE (O)	Year	50	Odour threshold at 4$\mu g/m^3$
Ethylene Glycol - Partic	HSE (O)	Year	25	VDP
Ethylene Glycol - Vapour	HSE (O)	Year	150	
n-Hexane	EPA	Year	0.2	(Cancer risk)
Methyl Acrylate	HSE (O)	Year	87.5	Odour threshold at 17.5$\mu g/m^3$
Methylethyl-ketone	EPA	Year	1000	
Methylisobutyl-ketone	HSE (O)	Year	500	(under review by EPA)
Methylmercaptan	HSE (O)	Year	2.5	

ORGANIC SUBSTANCES	Environmental Assessment Level			IARC Cancer Class (1f 1 or 2A) VDP = Vegetation Damage Potential BDP = Building Damage Potential (Footnote 3)
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)	
Nitrogenated Aliphatics:				
Acrylonitrile	WHO	Year	0.05	Class 2A
Ethylamine	HSE (O)	Year	45	
Methylamine	HSE (O)	Year	30	
Nitromethane	HSE (O)	Year	625	

ORGANIC SUBSTANCES	Environmental Assessment Level			IARC Cancer Class (1f 1 or 2A) VDP = Vegetation Damage Potential BDP = Building Damage Potential (Footnote 3)
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)	
Halogenated Aliphatics:				
Bromoform	EPA	Year	0.9	
Carbon Tetrachloride	EPA	Year	0.07	
Chloroform	EPA	Year	0.04	
1,2-Dibromoethane	EPA	Year	0.005	
1,1-Dichloroethane	HSE (O)	Year	$2mg/m^3$	
1,2-Dichloroethane	WHO	Year	700	
Dichloromethane	WHO	Year	3×10^{-10}	1×10^{-6} annual risk
Phosgene	HSE (O)	Year	1	
1,1,1-Trichloroethane	DK	Year	500	(under review by EPA)
1,1,2-Trichloroethane	HSE (O)	Year	110	

ORGANIC SUBSTANCES	Environmental Assessment Level			IARC Cancer Class (1f 1 or 2A) VDP = Vegetation Damage Potential BDP = Building Damage Potential (Footnote 3)
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)	
Vinyl Chloride	WHO	Continuous	1	Class 1 1 x 10 $^{-6}$L/T Risk
Aromatic Hydrocarbons:				
Benzene	Expert Panel on Air Quality Standards	Year	3.25	Class 1
Ethyl benzene	HSE (O)	Year	1mg/m^3	
PAHs:				
BaP	WHO	Year	1 x 10^{-5}	Carcinogenic
N_2 Aromatic HCs:				
Aniline	EPA	Year	1	
Dinitro-o-Cresol	HSE (O)	Year	0.5	
4.4-Methylene dianiline	HSE (O)	Year	2	
PANS	Not applicable			VDP

ORGANIC SUBSTANCES	Environmental Assessment Level			IARC Cancer Class (1f 1 or 2A) VDP = Vegetation Damage Potential BDP = Building Damage Potential (Footnote 3)
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)	
Trinitro-phenol	HSE (O)	Year	0.25	
Halogen-Aromatic HCs: Hexachloro-dibenzo-p-dioxin	EPA	Year	$0.8 pg/m^3$	
PCBs	HSE (O)	Year	1.25	
Polychlorinated terphenyls	EEL	Year	1.25	(as PCBs)
1,2,4 - Trichloro-benzene	HSE (O)	Year	100	

ORGANIC PESTICIDES	Environmental Assessment Level			IARC Cancer Class (1f 1 or 2A) VDP = Vegetation Damage Potential BDP = Building Damage Potential (Footnote 3)
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)	
Aldrin	EPA	Year	0.0002	
Atrazine (banned)	HSE (O)	Year	25	VDP
Azinthos-methyl	HSE (O)	Year	0.5	
DDT	EPA	Year	0.02	
Dichlorvos	HSE (O)	Year	2.5	(Under review by EPA)
Dieldrin	EPA	Year	0.0002	
Endosulfan	HSE (O)	Year	0.25	
Endrin	HSE (O)	Year	0.25	
Malathion	HSE (O)	Year	25	

FOOTNOTES TO TABLES- A3.2 (Air)

(1) SOURCES:

EPA - US EPA Integrated Risk Information System ('IRIS')

WHO - 1987 Air Quality Guidelines for Europe

HSE (O) - Occupational Exposure Standard } HSE Occupational Exposure Limits EH 40/93
HSE (M) - Maximum Exposure Limit } HSE Occupational Exposure Limits EH 40/93

(2) VALUES AND DERIVATION:

HSE - OELs

Long term
8 hour TWA

OES x 1/400 (as mg/m^3) } For year's exposure (x0.25)
MEL x 1/4000 } Health/environment safety factor (x 100 or 1000)
} As µg/m^3

(3) ODOUR AND VEGETATION:

Odour thresholds - From WHO above or HMIAPI Report } where value < EQS or EAL
Vegetation damage - From WHO above

Table A3.3 Environmental Quality Standards and Assessment levels for Surface Waters

NON-METALLIC INORGANIC SUBSTANCES	National/EC Directive EQS							Environmental Assessment Level (5) (T) = Total (D) = Dissolved
	Freshwater					Estuarine & Coastal		
	(Maxima) Abstraction for Drinking Water (2) DW1	DW2	DW3	Aquatic Life (3) Salm.	Cypr.	Estuary (4)	Coast (4)	
	(mg/l)					(mg/l)		(mg/l)
Ammonia (NH_4)	–	1.5	4	< 1	< 1	–	–	RQC 1A < 0.4 1B < 0.9
BOD (ATU)	–	–	–	< 5	< 8	–	–	RQC 1A < 3 1B < 5 2 < 9 3 < 17
Chlorine (HClO)	–	–	–	< 0.005	< 0.005	–	–	< 0.005
Chloride	–	–	–	–	–	–	–	500 (Agriculture)
Fluoride	1.5	–	–	–	–	–	–	1.5
Nitrate (NO_3)	50	50	50	–	–	–	–	50
Nitrite (NO_2)	–	–	–	< 0.2	< 0.5	–	–	Salm. < 0.2 Cyprin. < 0.5

NON-METALLIC INORGANIC SUBSTANCES	National/EC Directive EQS							Environmental Assessment Level (5) (T) = Total (D) = Dissolved
	Freshwater					Estuarine & Coastal		
	(Maxima) Abstraction for Drinking Water (2)			Aquatic Life (3)		Estuary	Coast	
	DW1	DW2	DW3	Salm.	Cypr.	(4)	(4)	
	(mg/l)					(mg/l)		(mg/l)
pH	6.8 - 8.5 (95% tile)	5.5 - 9 (95% tile)	-	6 - 9 (95% tile)	6 - 9 (95% tile)	-	6 - 8.5 (95% tile) 7- 8.5 (Shellfish)	Abstract 6.5 - 8.5 Salm. 6 - 9 Cyprin. 6 - 9 Salt 6/7 - 8.5
Sulphate (SO_4)	250	250	250	-	-	-	-	250
Suspended Solids	-	-	-	‹ 25	‹ 25	-	-	‹ 25

METALLIC AND ORGANO-METALLIC SUBSTANCES	National/EC Directive EQS							Environmental Assessment Level (5)
	Freshwater					Estuarine & Coastal		
	(Maxima)					Estuary	Coast	(T) = Total (D) = Dissolved
	Abstraction for Drinking Water (2)			Aquatic Life (3)		(4)	(4)	
	DW1	DW2	DW3	Salm.	Cypr.			
	(ug/l)					(µg/l)		(µg/l)
Arsenic	50	50	100	50 (Annual Average Dissolved)	50 (Annual Average Dissolved)		25	
Barium	100	1000	1000	–	–		–	1000 (T)
Boron	1000* (*95% tile)	1000* (*95% tile)	–	2000 (Annual Average Total)	2000 (Annual Average Total)		7000	Fresh 1000* (T) Salt 7000 (T)
Cadmium	5(T)	5(T)	5(T)	–	–		2.5(D)	Fresh 5 (T) Estuary 5 (D) Coast 2.5 (D)
Chromium	50(T)	50(T)	50(T)	–	–		15(D)	Abstract. 50 (T) Salt 15 (D)
	Total Hardness	< 50 50 – 100 100 – 150 150 – 200 200 – 250 <250		5 10 20 20 50 50	150 175 200 200 250 250			) Salm. (D)))) AS HARDNESS)) Cyprin. (D))

METALLIC AND ORGANO-METALLIC SUBSTANCES	National/EC Directive EQS							Environmental Assessment Level (5)
	Freshwater					Estuarine & Coastal		
	(Maxima) Abstraction for Drinking Water (2) DW1	DW2	DW3	Aquatic Life (3) Salm.	Cypr.	Estuary (4)	Coast (4)	(T) = Total (D) = Dissolved
	(ug/l)					(µg/l)		(µg/l)
	(mg/l. $CaCO_3$)	Annual Average - Dissolved						
Copper	50(T)		50(T)	-	-	-	5(D)	Abstract. 50 (T) Salt 5 (T)
	Total Hardness mg/l $CaCO_3$	< 50		1	1			) Salm. (D)
		50-100		6	6			)
		100-150		10	10			) AS HARDNESS
		150-200		10	10			)
		200-250		10	10			) Cyprin. (D)
		>250		28	28			)
Iron	300* (* 95% tile)	2000* (*95% tile)	-	1000	1000			Fresh 300* (D) Salt 1000 (D)

METALLIC AND ORGANO-METALLIC SUBSTANCES	National/EC Directive EQS							Environmental Assessment Level (5)
	Freshwater					Estuarine & Coastal		(T) = Total (D) = Dissolved
	(Maxima)					Estuary	Coast	
	Abstraction for Drinking Water (2)			Aquatic Life (3)				
	DW1	DW2	DW3	Salm.	Cypr.	(4)	(4)	
	(ug/l)					(µg/l)		(µg/l)
Lead	50(T)	50(T)	50(T)	–	–	–	25(D)	Abstract. 50 (T) Salt 25 (D)
	Total Hardness mg/t $CaCO_3$	< 50		4	50			) Salm. (D))) AS HARDNESS)) Cyprin. (D))
		50 – 100		10	125			
		100 – 150		10	125			
		150 – 200		20	250			
		200 – 250		20	250			
		>250		20	250			
		Annual Average – Dissolved						
Mercury	1(T)	1 (T)	1(T)	–	–	0.5(D)	0.3(D)	Fresh 1 (T) Estuary 0.5 (D) Coast 0.4n3 (D)
Nickel	50* (* 95% tile)	50* (* 95% tile)	–	–	–	–	30(D)	Abstract. 50*(T) Salt 30 (D)
	Total Hardness mg/t $CaCO_3$	< 50		50	50			) Salm. (D))) AS HARDNESS)) Cyprin. (D)
		50 – 100		100	100			
		100 – 150		150	150			
		150 – 200		150	150			
		200 – 250		200	200			
		>250		200	200			

METALLIC AND ORGANO-METALLIC SUBSTANCES	National/EC Directive EQS							Environmental Assessment Level (5)
	Freshwater					Estuarine & Coastal		
	(Maxima) Abstraction for Drinking Water (2)			Aquatic Life (3)		Estuary (4)	Coast (4)	(T) = Total (D) = Dissolved
	DW1	DW2	DW3	Salm.	Cypr.			
	(ug/l)					(µg/l)		(µg/l)
		Annual Average - Dissolved						
Organotins: TBT	0.02	0.02	-	0.02	0.02	-	0,002	Fresh 0.02 (T)
TPT	0.09	0.02	-	0.02	0.02	-	0.008	Salt 0.002 (T) Fresh 0.09 (T) Salt 0.008 (T)
Selenium								20 (Irrigation)
Vanadium	-	-	-	-	-	-	100(T)	Salt 100 (T)
	Total Hardness	0 - 200 > 200	200 200	20 60	20 60			) Salm. (T)) Cyprin. (T)) AS HARDNESS
		Annual average - Total						

METALLIC AND ORGANO-METALLIC SUBSTANCES	National/EC Directive EQS							Environmental Assessment Level (5)
	Freshwater					Estuarine & Coastal		
	(Maxima)					Estuary	Coast	(T) = Total (D) = Dissolved
	Abstraction for Drinking Water (2)			Aquatic Life (3)				
	DW1	DW2	DW3	Salm.	Cypr.	(4)	(4)	
	(ug/l)					(µg/l)		(µg/l)
Zinc	3000(T)	5000(T)	5000(T)	–			40(D)	Abstract. 3000 (T) Salt 40 (D)
	Total Hardness mg/t $CaCO_3$	< 50		8	75			) Salm. (T)
		50 – 100		50	175			)
		100 – 150		75	250			) AS HARDNESS
		150 – 200		75	250			)
		200 – 250		75	250			) Cyprin. (T)
		>250		125	500			)
		Annual Average – Dissolved						

ORGANIC SUBSTANCES (EXCL. PESTICIDES)		National/EC Directive EQS Freshwater					Estuarine & Coastal			Environmental Assessment Level (5) (T) = Total (D) = Dissolved
	Dangerous Substances (1) (Annual Mean)	(Maxima) Abstraction for Drinking Water (2) DW1	DW2	DW3	Aquatic Life (3) Salm.	Cypr.	Dangerous Substances (1) (An. Mean) (Coastal)	Estuary (4)	Coast (4)	
	(µg/l)						(µg/l)			(µg/l)
Carbon tetrachloride	12	–	–	–	–	–	12	12	12	12
Chloroform	12	–	–	–	–	–	12	12	12	12
Cyanide	–	50	50	50	–	–	–	–	–	Abstract. 50
1,2 Dichloroethane	10	–	–	–	–	–	10	–	–	10
Hexachlorobenzene	0.03	–	–	–	–	–	0.03	0.03	0.03	0.03
Hexachlorobutadiene	0.1	–	–	–	–	–	0.1	0.1	0.1	0.1
Hydrocarbons (soluble)	–	50	200	1000	–	–	–	–	–	Abstract. 50

ORGANIC SUBSTANCES (EXCL. PESTICIDES)	National/EC Directive EQS									Environmental Assessment Level (5) (T) = Total (D) = Dissolved
	Freshwater						Estuarine & Coastal			
	Dangerous Substances (1) (Annual Mean)	(Maxima) Abstraction for Drinking Water (2)			Aquatic Life (3)		Dangerous Substances (1) (An. Mean) (Coastal)	Estuary (4)	Coast (4)	
		DW1	DW2	DW3	Salm.	Cypr.				
	(µg/l)						(µg/l)			(µg/l)
PAHs	-	0.2	0.2	1	-	-	-	-	-	Abstract. 0.2
Phenols	-	1	5	100	-	-	-	-	-	Abstract. 1
Trichlorobenzene (all isomers)	0.4	-	-	-	-	-	0.4	-	-	0.4
Trichlorethylene	10	-	-	-	-	-	10	-	-	10
Perchloroethylene	10	-	-	-	-	-	10	-	-	10

ORGANIC PESTICIDES	National/EC Directive EQS									Environmental Assessment Level (5)
	Freshwater						Estuarine & Coastal			(T) = Total (D) = Dissolved
	Dangerous Substances (1) (Annual Mean)	(Maxima) Abstraction for Drinking Water (2) DW1	DW2	DW3	Aquatic Life (3) Salm.	Cypr.	Dangerous Substances (1) (An. Mean) (Coastal)	Estuary (4)	Coast (4)	
[* = EQS proposed]	(µg/l)						(µg/l)			(µg/l)
Atrazine + Simazine*	2	–	–	–	–	–	2	–	–	2
Aldrin + Dieldrin + Endrin + Isodrin = Total Drins	0.005 0.03	– –	– –	– –	– –	– –	0.005 0.03	– –	– –	0.005 0.03
Azinthosmethyl*	0.01	–	–	–	–	–	0.01	–	–	0.01
DDT (all isomers)	0.025	–	–	–	–	–	0.025	–	–	0.025
P-P-DDT	0.01	–	–	–	–	–	0.01	–	–	0.01
Cyfluthrin		0.001	0.001	–	0.001	0.001	–	–	0.001	0.001 (95% tile)
Dichlorovos*	0.001	–	–	–	–	–	0.04	–	–	Fresh 0.001 Salt 0.004
HCH (all isomers)	0.1	–	–	–	–	–	0.02	–	–	Fresh 0.1 Salt 0.02

ORGANIC PESTICIDES	National/EC Directive EQS									Environmental Assessment Level (5)
	Freshwater						Estuarine & Coastal			(T) = Total (D) = Dissolved
	Dangerous Substances (1) (Annual Mean)	(Maxima) Abstraction for Drinking Water (2)			Aquatic Life (3)		Dangerous Substances (1) (An. Mean) (Coastal)	Estuary (4)	Coast (4)	
		DW1	DW2	DW3	Salm.	Cypr.				
[* = EQS proposed]	(µg/l)						(µg/l)			(µg/l)
Fenitrothion*	0.01	–	–	–	–	–	0.01	–	–	0.01
Malathion*	0.01	–	–	–	–	–	0.02	–	–	Fresh 0.01 Salt 0.02
PCP & compounds	2	–	–	–	–	–	2	–	–	2
Flucofuron	–	–	–	–	–	1	–	–	1	1 (95% tile)
Total Pesticides (Parathion, BHC, Dieldrin)	–	1	2.5	5	–	–	–	–	–	Abstract. 1

ORGANIC PESTICIDES	National/EC Directive EQS									Environmental Assessment Level (5) (T) = Total (D) = Dissolved
	Freshwater						Estuarine & Coastal			
		(Maxima)								
	Dangerous Substances (1) (Annual Mean)	Abstraction for Drinking Water (2) DW1	DW2	DW3	Aquatic Life (3) Salm.	Cypr.	Dangerous Substances (1) (An. Mean) (Coastal)	Estuary (4)	Coast (4)	
[* = EQS proposed]	(µg/l)						(µg/l)			(µg/l)
Endosulphan*	0.003	–	–	–	–	–	0.003	–	–	0.003
Permethrin	–	0.01	0.01	–	0.01	0.01	–	–	0.01	0.01 (95% tile)
PCSDs	–	–	–	–	0.05	0.05	–	–	0.05	0.05 (95% tile)
Simazine + Atrazine*	2	–	–	–	–	–	2	–	–	2
Sulcofuran	–	–	–	–	25	25	–	–	25	25 (95% tile)
Trifluralin*	0.1	–	–	–	–	–	0.1	–	–	0.1

FOOTNOTES TO TABLE A3.3 - Water

(1) - SI 2286/89 (Dangerous Substances regulations)
OR proposed in 11/91 DoE Consultation Paper (EQSs for Dangerous Substances)
OR in 90/415/EEC (List I Dangerous Substances)

(2) - SI 1148/89 (Surface Water regulations)
OR Circular 7/89 (Dangerous substances Directives implementation)

(3) - Circular 7/89
OR 78/659 EEC (Water quality for fish)

(4) - Circular 7/89
OR proposed in 11/91 Consultation Paper
OR in 90/415/EEC

(5) - RQC = River Quality Classification (For national river quality surveys)

Table A3.4 EQSs, guideline values and expected concentrations of some contaminants in biota.

METALS	
Mercury	EQS - mean concentrations of mercury in representative fish flesh to be less than 0.3 mg/kg wet weight (European Community and Paris Commission). Guidelines with a mid range of 0.1 - 0.3 mg/kg of mercury in fish flesh (wet weight). (Oslo and Paris Commissions).
Cadmium	No standards or guidelines in England and Wales. Expected values are less than 0.2 mg/kg wet weight.
Lead	GB Lead in Food Regulations 1979 - concentrations in fish should not exceed 2.0 mg/kg wet weight. Expected values are 0.2 - 0.3 mg/kg wet weight in fish.
Copper	UK recommendations for limits for copper content of food are that levels should not exceed 20 mg/kg wet weight in fish. Expected values in fish are up to 0.6 mg/kg wet weight, and greater than 1.0 mg/kg wet weight in fatty fish such as herring.
Zinc	UK guidelines (1953) on levels of zinc in food are that levels should not exceed 50 mg/kg wet weight, except in some foods which naturally contain more than 50 mg/kg such as herring. Expected values commonly found are up to 6.0 mg/kg wet weight in most fish flesh and in excess of 10 mg/kg in fatty fish.
PESTICIDES, PCBS & DIOXINS	
There are no set standards for concentrations of these substances in fish and shellfish.	
Dieldrin	Expected values are 0.2 - 0.3 mg/kg wet weight in fish liver.
PCBs	Oslo and Paris Commissions (JMP) guidelines have a mid range of 0.01 - 0.05 mg/kg wet weight in fish muscle, 2.0 - 5.0 mg/kg wet weight in cod liver and 0.5 - 1.0 mg/kg wet weight in flounder liver. Guideline values for cod and flounder are used by MAFF as guidelines for concentrations in all round fish and flatfish respectively

Table A3.5 Maximum deposition rates for soils

NON METALLIC INORGANIC SUBSTANCES	Soil Quality Criteria			Maximum Deposition Rates (mg/m^2/day)
	Maximum permissable concentration after sewage sludge addition (mg/kg dry)	Contaminated Land 'Trigger' Values (mg/kg dry)		
		UK	NL	
	(1)	(2)	(3)	
Boron		3 (Soluble)		0.0035
Bromides			50 (Total)	0.06
Cyanide - Free - Complex	(25) (250)		10 50 (Total)	0.02 0.1
Fluorides		500	400 (Total)	0.2

Table A3.5 Maximum deposition rates for soils (Continued)

METALLIC AND ORGANO-METALLIC SUBSTANCES	Soil Quality Criteria			Maximum Deposition Rates ($mg/m^2/day$)
	Maximum permissable concentration after sewage sludge addition (mg/kg dry)	Contaminated Land 'Trigger' Values (mg/kg dry)		
		UK	NL	
	(1)	(2)	(3)	
Arsenic	(50)	50	30	0.05
arium			400	0.4
Cadmium	3	3	5	0.004
Chromium (Total)	(400)	600	250	0.3
Cobalt			50	0.08
Copper	80-200 pH dependent	250	100	0.16
Lead	300	300-500	150	0.26

METALLIC AND ORGANO-METALLIC SUBSTANCES	Soil Quality Criteria			Maximum Deposition Rates ($mg/m^2/day$)
	Maximum permissable concentration after sewage sludge addition (mg/kg dry)	Contaminated Land 'Trigger' Values (mg/kg dry)		
		UK	NL	
	(1)	(2)	(3)	
Mercury	1		2	0.003
Molybdenum	(4)		40	0.004
Nickel	50-110 pH dependent		100	0.1
Selenium	(3)			0.006
Tin			50	0.08
Zinc	200-450 pH dependent	1000	500	0.8

ORGANIC SUBSTANCES	Typical Soil ½ Life (days)	Soil Quality Criteria			Maximum Deposition Rates (mg/m^2/day)
		Maximum permissable concentration after sewage sludge addition (mg/kg dry)	Contaminated Land 'Trigger' Values (mg/kg dry)		
			UK	NL	
		(1)	(2)	(3)	
Aromatics-Total	15			7	0.014
Benzene	10			0.5	0.001
Chlorinated aliphatic organics:	50			7 (tot)	0.014
Chlorobenzenes	100			2 (Tot)	0.004
Chlorophenols	10			1 (Tot)	0.002
Ethyl benzene	7			5	0.01

ORGANIC SUBSTANCES	Typical Soil ½ Life (days)	Soil Quality Criteria			Maximum Deposition Rates (mg/m^2/day)
		Maximum permissable concentration after sewage sludge addition (mg/kg dry)	Contaminated Land 'Trigger' Values (mg/kg dry)		
		(1)	UK (2)	NL (3)	
PAHs	365		50	20 (Total)	0.04
Perchloroethylene	175				–
PCP	50				0.002
PCBs	N/D			1 (Total)	0.002
Phenols	4		5	1	
					–

ORGANIC SUBSTANCES	Typical Soil ½ Life (days)	Soil Quality Criteria			Maximum Deposition Rates (mg/m^2/day)
		Maximum permissable concentration after sewage sludge addition (mg/kg dry)	Contaminated Land 'Trigger' Values (mg/kg dry)		
			UK	NL	
		(1)	(2)	(3)	
Toluene	13			3	0.006
Xylene	18			5	0.01
Pesticides	365			0.5	0.0008
-OC-Individual				1	0.002
-OC-Total				2	0.004
Total					

FOOTNOTES TO TABLE A3.5 - (SOIL)

(1) SI 1263/89 – Sludge (Use in Agriculture) Regulations (HMSO 1989) - Soil limit values.

Values in Brackets – Code of Practice for agricultural use of sludge - Soil limit recommendations from DOE (1989)

(2) Development of contaminated land, UK Interdepartmental Committee, Guidance Notes 59/83 (ICRCL 1987) and 70/90 (ICRCL 1990) - threshold trigger concentrations

(3) Soil protection and remediation - Soil quality criteria - Indicative values Moen et al (1985), soil protection & remedial actions, Proc. 1st Internat. Conf. on Contaminated soil (Utrecht '85), Nijhoff, Dordrecht.

N/D No data

Table A4.2 Environmental assessment Levels for short term effects from air pollutants

INORGANIC NON METALLIC SUBSTANCES	Environmental Assessment Level		
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)
Ammonia	HSE (O)	10 mins	240
Carbon Monoxide	WHO	15 mins	100mg/m^3
Carbon Disulphide	WHO	24 hrs	100
Hydrogen Cyanide	HSE (M)	10 mins	10
Hydrogen Sulphide	WHO	24 hrs	150
Nitric Acid	HSE (O)	10 mins	100
Nitrogen Dioxide NOx	WHO	1 hr 24 hrs	400 150
Nitrous Oxide	HSE (O)	10 mins	5 mg/m^3
Sulphur Dioxide	EC (Mand.)	98% of daily means over year. Max. exceedance 3 days	Smoke 250 > 150 350 < 150
Suspended Particulates	EC (Mand.)	95% tile daily means over year.	300
Phosphorous	HSE (O)	10 mins	3
Ozone	WHO	1 hr 8 hrs	150–200 100–120
Halogens/Halides:			
Bromine	HSE (O)	10 mins	20
Chlorine	HSE (O)	10 mins	30
Chlorine dioxide	HSE (O)	10 mins	9
Fluorine (Sol.Fl)	HSE (O)	10 mins	15
Fluorides	NL (NS)	24 hrs	3
Iodine	HSE (O)	10 mins	10

INORGANIC NON METALLIC SUBSTANCES	Environmental Assessment Level		
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)
Hydrochloric Acid	HSE (O)	10 mins	70
Hydrogen Fluoride	HSE (O)	10 mins	25

Table A4.2 Environmental assessment Levels for short term effects from air pollutants

METALLIC AND ORGANO METALLIC SUBSTANCES	Environmental Assessment Level		
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)
Antimony	HSE (O)	10 mins	15
Arsenic	HSE (M)	10 mins	0.3
Barium (Sol.)	HSE (O)	10 mins	15
Beryllium	HSE (Rev.)	10 mins	0.06
Boron ($B_2 0_3$)	HSE (O)	10 mins	200
Cadmium	HSE (M)	10 mins	0.15
Chromium (III)	HSE (O)	10 mins	10
(VI)		10 mins	
Chromium (VI)	HSE (M)		0.15
Cobalt	HSE (Rev.)	10 mins	3
Copper (Fume/Dust)	HSE (O)	10 mins	6
Iron oxide (fume)	HSE (O)	10 mins	100
Iron Salts	HSE (O)	10 mins	20
Lead	NL (S)	24 hrs 98% tile	2
Tetraethyl - lead	HSE (O)	10 mins	3
Manganese	HSE (O)	10 mins	30
Mercury			
- Inorganic	HSE (O)	10 mins	1.5
- Organic - (meth.)	HSE (O)	10 mins	0.3
Molybdenum			
- soluble	HSE (O)	10 mins	100
- insoluble	HSE (O)	10 mins	200
Nickel	HSE (M)	10 mins	1.5
- Carbonyl	HSE (O)	10 mins	2.4
Platinum	HSE (O)	10 mins	150
- Sol. Salts	HSE (O)	10 mins	0.06
Selenium	HSE (O)	10 mins	3
Tin - Inorganic	HSE (O)	10 min	40
- Organic	HSE (O)	10 mins	2
Titanium dioxide	HSE (O)	10 mins	150

METALLIC AND ORGANO METALLIC SUBSTANCES	Environmental Assessment Level		
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)
Vanadium Pentoxide (fume & dust)	HSE (O)	10 mins	1.5
Vanadium Pentoxide (tol. inhal. dust)	HSE (O)	10 mins	15
Zinc - Zn Cl	HSE (O)	10 mins	20

Table A4.2 Environmental assessment Levels for short term effects from air pollutants

ORGANIC SUBSTANCES	Environmental Assessment Level		
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)
Aliphatics:			
Acetaldehyde	HSE (Rev.)	10 mins	2.7 mg/m^3
Acetone	HSE (O)	10 mins	36 mg/m^3
Acetonitrile	HSE (O)	10 mins	1 mg/m^3
Acrylic Acid	HSE (O)	10 mins	600
Amyl Acetate (pentyl)	HSE (O)	10 mins	8 mg/m^3
1,3 - Butadiene	HSE (M)	10 mins	66
n-Butylacrylate	HSE (O)	10 mins	1.65 mg/m^3
Carbon Disulphide	WHO	24 hrs	100
Ethyl Acrylate	HSE (O)	10 mins	600
Ethylene Glycol - Partic.	HSE (O)	10 mins	300
Ethylene Glycol - Vapour	HSE (O)	10 mins	1.25 mg/m^3
Formaldehyde	WHO	30 mins	100
n-Hexane	HSE (O)	10 mins	2.1 mg/m^3
Methanol	HSE (O)	10 mins	3.1 mg/m^3
Methyl Acetate	HSE (O)	10 mins	7.6 mg/m^3
Methyl Acrylate	HSE (O)	10 mins	8 mg/m^3
Methylethyl-ketone	HSE (O)	10 mins	9 mg/m^3
Methylisobutyl-ketone	HSE (O)	10 mins	3 mg/m^3
Methylmercaptan	HSE (O)	10 mins	30
Nitrogenated Aliphatics:			
Acrylonitrile	HSE (M)	10 mins	12
Ethylamine	HSE (O)	10 mins	540
Methylamine	HSE (O)	10 mins	360
Nitromethane	HSE (O)	10 mins	3.75 mg/m^3

ORGANIC SUBSTANCES	Environmental Assessment Level		
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)
Halogenated Aliphatics:			
Bromoform	HSE (O)	10 mins	150
Carbon Tetrachloride	HSE (O)	10 mins	380
Chloroform	HSE (O)	10 mins	300
1,2-Dibromoethane	HSE (M)	10 mins	12
1,1-Dichloroethane	HSE (O)	10 mins	16 mg/m^3
1,2-Dichloroethane	WHO	24 hrs	700
Dichloromethane	WHO	24 hrs	3 mg/m^3
Phosgene	HSE (O)	10 mins	12
Tetrachloroethylene	WHO	24 hrs	5 mg/m^3
1,1,1-Trichloroethane	HSE (M)	10 mins	25 mg/m^3
1,1,2-Trichloroethane	HSE (Rev.)	10 mins	900
Trichloroethylene	HSE (M)	10 mins	800
Vinyl Chloride	HSE (M)	10 mins	55
Aromatic Hydrocarbons:			
Benzene	HSE (M)	10 mins	50
Cumene	HSE (O)	10 mins	3.5 mg/m^3
Ethyl benzene	HSE (O)	10 mins	5.5 mg/m^3
Styrene	WHO	24 hrs	800
Toluene	WHO	24 hrs	8 mg/m^3
Xylenes	HSE (O)	10 mins	6.5 mg/m^3
PAHs:			
Napthalene	HSE (O)	10 mins	750

ORGANIC SUBSTANCES	Environmental Assessment Level		
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)
Oxygen Aromatic HCs: Phenol	HSE (O)	10 mins	380
N_2 Aromatic HCs: Aniline	HSE (Rev.)	10 mins	200
Dinitro-o-Cresol	HSE (O)	10 mins	6
4,4-Methylene dianiline	HSE (Rev.)	10 mins	40
Pyridine	HSE (O)	10 mins	300
Toluene di-isocyanate (isocyanates)	HSE (M)	10 mins	7
Trinitro-phenol	HSE (O)	10 mins	3
Halogen-Aromatic HCs:			
PCBs	HSE (Rev.)	10 mins	10
1,2,4 - Trichloro-benzene	HSE (O)	10 mins	400

ORGANIC PESTICIDES	Environmental Assessment Level		
	Source (Footnote 1)	Reference Period	Value ($\mu g/m^3$) (Footnote 2)
Aldrin	HSE (O)	10 mins	7.5
Atrazine (banned)	HSE (Rev.)	10 mins	300
Azinthos-methyl	HSE (O)	10 mins	80
DDT	HSE (O)	10 mins	30
Dichlorvos	HSE (O)	10 mins	30
Dieldrin	HSE (O)	10 mins	7.5
Endosulfan	HSE (O)	10 mins	3
Endrin	HSE (O)	10 mins	3
HCH (Y-BHC)	HSE (O)	10 mins	15
Malathion	HSE (O)	10 mins	300
PCP	HSE (O)	10 mins	15

FOOTNOTES TO TABLE - A4.2 - SHORT TERM

(1) **SOURCES:**

WHO - 1987 Air Quality Guidelines for Europe

HSE (O) - Occupational Exposure Standard } HSE } Occupational } Exposure limit } EH40/93

HSE (M) - Maximum Exposure Limit

NL (S) & NL (NS) - Dutch S = statutory NS = non statu standards

(2) **VALUES AND DERIVATION:**

HSE - Occupational Exposure Limits:

Short term - MEL X 1/1000 safety factor

- OES X 1/100 safety factor

If only long term exposure limit as 8hr TWA is available value is multiplied by 3 to approximate 10 minute Short Term Exposure Limit (HSE 1993)

ANNEX B HAZARD ASSESSMENT OF WASTES ARISING FROM PRESCRIBED PROCESSES

B1.0 INTRODUCTION

138 This annex proposes a method for assessing the potential environmental hazards of releases to enable different options to be compared and ranked.

B2.0 PROPOSED SCHEME

139 In general two different approaches to hazard assessment can be identified. One approach is based on a hierarchical decision tree type of structure. This approach requires parameters to be given an order of importance as some characteristics will be considered higher up the 'tree' than others. Moreover the hierarchical structure tends to identify those compounds of concern but does not distinguish between them.

140 The second approach adopts a scoring system where factors representing the degree of exposure and 'toxicity' of the substance are allocated scores. Parameters of concern attract higher scores and a final hazard assessment is obtained by combining the scores in some way. This approach enables the relative hazard represented by a wide range of chemicals to be assessed.

141 In the proposed scheme, two main routes of exposure have been identified, via air and water. It is considered that whilst for some highly volatile substances the main exposure route will be via the air, for the majority of chemicals the aquatic route will be the most significant. Consequently in carrying out the assessment the potential hazard posed by a particular chemical will be determined separately for air and water and then combined to give an overall hazard score. This 'Unit Hazard Score' can then be

modified by the site specific quantity of the substance being considered to generate an overall score for the substance produced by the particular process option at that location.

B3.0 EXPOSURE ASSESSMENT

B3.1 WATER

B3.1.1 Solubility (S)

142 The potential mobility of the pollutant into ground or surface water will in part be determined by its solubility. Substances with high solubility will be relatively more mobile than those of lower solubility. The score for the most soluble form (where appropriate) should be used. For inorganic compounds this will usually be the chloride or nitrate)

Solubility in water of most soluble form (mg/l)[7]	Score
>1000	5
>100 - 1000	4
>10 - 100	3
>1 - 10	2
<1	1

B3.1.2 Adsorption (A)

143 Adsorption can be considered as the binding of a substance to the surface of a particle. Substances which are readily adsorbed might be expected to be bound to sediment in the

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[7] Where no solubility data is available a default value of 4 should be used.

aqueous phase. The potential for adsorption onto organic matter for non-ionic compounds can be related to the organic carbon partition coefficient (K_{oc}) for the substance concerned.

Log_{10} K_{oc}	Score
<0.5	5
>0.5 - 1.0	4
>1.0 - 1.5	3
>1.5 - 2.0	2
>2.0	1

Where K_{oc} is unavailable it may be estimated from;

$$Log_{10}\ K_{oc} = Log_{10}K_{ow} - 0.317$$

where, K_{ow} is the Octanol\Water partition coefficient for the substance concerned.

144 For ionic compounds the degree of mobility will depend principally on the solubility of the substance, which in turn is determined to a great extent by the Ph. If conditions are favourable, some substances such as heavy metals may be converted into an insoluble form (eg sulphide or carbonate) (Sumner 1978). For ionic compounds 'adsorption' should be scored on the basis of the solubility of the most insoluble form using the scoring system in section 5.1.1. Under these circumstances, a substance may be scored twice on the basis of solubility, once for the most soluble form and once for the insoluble form.

145 Where no data on adsorption or minimum solubility is available a default value of 4 should be used.

B3.1.3 Degradation (D_w)

146 The persistence of a substance will affect the degree to which a receptor may be exposed to the pollutant. Persistence is scored on the potential for degradation within the soil/water compartment.

147 A variety of degradation data may be available, the following scoring system is based on BRE (1991). The sources of data should be used in descending order of preference. If no data of any type exist then a default value of 4 should be used.

Source of data	Data value	Score
Ready biodegredability testing	>70% degraded in 28 days	1
	20 - 70% degraded in 28 days	2
	<20% degraded in 28 days	4
Inherent testing	>30% degraded	2
	<30% degraded	4
BOD_5/COD or ThOD ratio	>0.7	1
	0.2 - 0.7	2
	<0.2	4
Half-life	In the order of weeks	1
	In the order of months	2
	In the order of years	4

B3.1.4 Bioaccumulation Potential (B_w)

148 Substances may be taken up by organisms at one trophic level in the food chain and consumed by members of a different level. Bioaccumulation may either be measured directly (preferred) or estimated from K_{ow}, the octanol/water partition coefficient.

149 Bioaccumulation is considered only for the aquatic exposure route since it is considered unlikely that highly volatile substances will be readily accumulated. This is supported

by a review of the data for 89 priority organic substances (CRC 1992) which indicated that where the vapour pressure was high (>100 kPa at 25°C) the potential for bioaccumulation was low ($\log_{10} K_{ow} >2$).

Source of data	Data value	Score
Observed bioaccumulation potential (BCF)	<=10	1
	> 10 - 100	1.5
	> 100	2
Estimated from Log_{10} K_{ow}.	<=1	1
	1 - 2	1.2
	2 - 3	1.4
	3 - 4	1.6
	4 - 5	1.8
	>5	2

If no data of either type are available then a default value of 1.5 should be used.

B3.2 AIR

B3.2.1 Volatility (V)

150 For some volatile substances, particularly solvents, evaporation may be quite high. For other substances with a relatively low volatility the potential exposure via this route will be small. The following table provides a means of taking this into account in the hazard assessment.

Volatility at 25° C	Score
>= 100 kPa	4
10 - <100	3
1 - <10 kPa	2
<1 kPa	1

Where no information is available a default value of 2.5 should be used.

B3.2.1 Degradation in Air (D_a)

151 The degradation rate of a substance in the atmosphere will to some extent determine the exposure of a particular target organism either directly or via deposition and subsequent uptake. It is recognised that other processes such as wet or dry deposition may reduce the residence time of a pollutant in the atmosphere but these are generally related to atmospheric conditions and cannot be taken into consideration in this scheme.

152 To deal with the wide variety of degradation data available it is proposed that scoring is based on the general order of magnitude of the degradation rate exhibited by the substance.

Atmospheric degradation rate	Score
In the order of weeks	1
In the order of months	2
In the order of years	4

If no data are available then a default score of 2 should be used.

B4.0 EFFECTS ASSESSMENT

B4.1 WATER

B4.1.1 Aquatic toxicity (AQT)

153 The approach to scoring of aquatic toxicity is based on BRE (1991). The score can be based on two types of data, acute or chronic toxicity. Chronic toxicity is preferred as it is thought to be more relevant to the long term exposure of aquatic organisms to low levels of pollutants. If data for more than one species exist, worst case data should be used. In the absence of chronic data, acute data should be used.

Source of data	Concentration at which an effect is shown (mg/l)	Score
Chronic toxicity test	>10	1
	>1 - 10	2
	>0.1 - 1	3
	>0.01 - 0.1	4
	>0.001 - 0.01	5
	<=0.001	6
Acute toxicity test (LC_{50}, EC_{50}, IC_{50})	>100	1
	>10 - 100	2
	>1 - 10	3
	>0.1 - 1	4
	>0.01 - 0.1	5
	<=0.01	6

B4.1.1 Mammalian toxicity (MT_w)

154 The mammalian toxicity score is modified from that proposed by Shillaker (1991) to consider exposure by dermal or oral routes only. The consideration of mammalian toxicity needs to take into account two effects, direct effects such as acute or repeated toxicity, irritation and sensitisation and secondly, carcinogenic and reproductive effects. These two types of effect are scored separately and then combined to give an overall aquatic mammalian toxicity score.

155 The toxicity scores are based on the R-phrases (Risk phrases) as defined under the Classification, Packaging and Labelling of dangerous substances Directive.

B4.1.2 Direct mammalian effects (DME_w)

156 The pollutant may lead to a number of different effects on the target organism. The magnitude of each effect should be identified from the appropriate R_Phrase and scored accordingly. The maximum value should be selected to represent the direct aquatic mammalian toxicity of the substance.

157 Where there is no information on the direct effects of the substance to mammals a default value of 4 should be used.

Mode of action	Severity of effect	R-Phrase	Score
Acute toxicity	Very toxic	27/28	6
	Toxic	24/25	4
	Harmful	21/22	2

Mode of action	Severity of effect	R–Phrase	Score
	No R Phrase required		1
Irritation /corrosion	Any irritation or corrosive effects	34/35/36/ 38/39/41	2
	No R Phrase required		1
Sensitisation	Skin sensitiser	43	4
	No R Phrase required		1
Repeated exposure effects	Serious damage to health	48	6
	Cumulative effects	33	4
	No R phrase required		1

B4.1.3 Mammalian reproductive or mutagenic effects. (MRM$_w$)

158 The substance may lead to mutagenic or effects on reproduction and should be scored according to the scheme outlined below. The maximum score of either reproductive or mutagenic effects should then be identified.

Mode of action	Score criteria	Score
Mutagenicity	Labelled for carcinogenicity or mutagenicity (R-Phrase 45) or classified as a Group 1 or Group 2 carcinogen by IARC.	9
	Substances which give cause for concern owing to possible carcinogenic effects (R-Phrase 40) or there is significant evidence of DNA damage, Mutation, Chromosomal abnormalities or other effects according to IARC.	6
	Tests for gene mutation (*in vitro*) and for chromosome aberrations in somatic cells (*in vitro* or *in vivo*) conducted and all negative.	1
Reproductive toxicity	Labelled for toxicity to reproduction or positive in a reproductive toxicity test. (R -Phrases 46/47/60/61/62/63/64)	9
	Tests in somatic cells for mutagenicity positive (R-Phrase 40)	6
	Negative in fertility and teratogenicity tests.	1

159 Where no data are available as to whether an R-Phrase has been awarded or there is no IARC classification or information then a default value of 4 should be assigned. The maximum score from these two effects is carried forward into the calculation of the aquatic toxicity score.

B4.2 AIR TOXICITY

B4.2.1 Direct Mammalian toxicity (DME_a)

160 An organism exposed to a substance in air my exhibit a number of different effects. The magnitude of each effect should be identified from the appropriate R_Phrase and scored accordingly. The maximum value should be selected to represent the direct mammalian toxicity for exposure to air for the substance.

161 An organism exposed to a substance in air my exhibit a number of different effects. The magnitude of each effect should be identified from the appropriate R_Phrase and scored accordingly. The maximum value should be selected to represent the direct mammalian toxicity for exposure to air for the substance.

162 Where there is no information on the direct effects of the substance to mammals a default value of 4 should be used.

Mode of action	Severity of effect	R-Phrase	Score
Acute toxicity	Very toxic	26	6
	Toxic	23	4
	Harmful	20	2
	No R Phrase required		1
Irritation /corrosion	Any irritation or corrosive effects	34/35/36/37/ 38/39/41	2

Mode of action	Severity of effect	R-Phrase	Score
	No R Phrase required		1
Sensitisation	Respiratory sensitizer	42	9
	Skin sensitiser	43	4
	No R Phrase required		1
Repeated exposure effects	Serious damage to health	48	6
	Cumulative effects	33	4
	No R phrase required		1

B4.2.2 Reproductive or mutagenic effects from exposure to air (MRM_a)

163 The substance may give rise to mutagenic or effects on reproduction and should be scored according to the scheme outlined below. The maximum score of either reproductive or mutagenic effects should then be identified.

Mode of action	Score criteria	Score
Mutagenicity	Labelled for carcinogenicity or mutagenicity (R-Phrases 45/49) or classified as a Group 1 or Group 2 carcinogen by IARC.	9
	Substances which give cause for concern owing to possible carcinogenic effects (R-Phrase 40) or there is significant evidence of DNA damage, Mutation, Chromosomal abnormalities or other effects according to IARC.	6
	Tests for gene mutation (*in vitro*) and for chromosome aberrations in somatic cells (*in vitro* or *in vivo*) conducted and all negative.	1
Reproductive toxicity	Labelled for toxicity to reproduction or positive in a reproductive toxicity test. (R-Phrases 46/47/60/61/62/63/64)	9
	Tests in somatic cells for mutagenicity positive (R-Phrase 40)	6
	Negative in fertility and teratogenicity tests.	1

164 Where no data are available as to whether an R-Phrase has been awarded or there is no IARC classification or information then a default value of 4 should be assigned. The maximum score from these two effects is carried forward into the calculation of the aquatic toxicity score.

B4.3 CALCULATION OF TOXICITY SCORE (T)

165 To take account of the difference in exposure routes the toxicity scores for air and water are determined separately. For each medium the maximum score for the mammalian direct effects (DME) and mutagenic/reproductive effects are identified and summed. In the case of water the non-mammalian toxicity score (AQT) is also added to the total. ie;

$$Aquatic\ Toxicity\ Score\ (T_w) = AQT + Max(DME_w) + Max(MRM_w)$$

$$Air\ Toxicity\ Score\ (T_a) = Max(DME_a) + Max(MRM_a)$$

B5.0 CALCULATION OF UNIT HAZARD SCORE

166 The hazard score for each of the two exposure routes is obtained by multiplying the appropriate exposure and toxicity factors together. ie;

$$Unit\ Hazard\ Score_w = S * A * D_w * B_w * T_w$$

$$Unit\ Hazard\ Score_a = V * D_a * T_a$$

167 The overall Unit hazard Score is then obtained by summing the medium specific values, as follows;

$$Unit\ Hazard\ Score_{Total} = UH_w + UH_a$$

168 Where UH_w and UH_a represent the Unit Hazard Scores for water and air respectively.

169 The overall Unit Hazard scores for a range of substances are shown in Table B1.

170 The final site specific score which takes into account the quantity disposed of is given by;

$$Final\ Score = Log_{10}(Quantity\ disposed\ of\ (t/a)) * Overall\ Unit\ h$$

Table B1 Example Unit Hazard Scores for some inorganic and organic substances.

Substance	Exposure Score		Toxicity Score		Unit hazard Score		Total Unit hazard Score
	Water	Air	Water	Air	Water	Air	
Cadmium	80	1	19	13	1520	13	1533
Nickel	80	1	15	10	1200	10	1210
Vinyl chloride	72	4	13	10	936	40	976
Benzene	28	3	18	15	504	45	549
Mercury	40	4	12	6	480	24	504
Acrylo-nitrile	25	3	16	11	400	33	433
Form-aldehyde	25	10	13	10	325	100	425
Chromium	40	1	17	13	680	13	693

Substance	Exposure Score		Toxicity Score		Unit hazard Score		Total Unit hazard Score
	Water	Air	Water	Air	Water	Air	
Dichloro-methane	24	6	8	10	192	60	252
Ethyl benzene	12.8	5	13	10	166.4	50	216.4
1,3 Butadiene	9.6	4	14	13	134.4	52	186.4
Methyl ethyl ketone	25	2	5	1	125	2	127
Styrene	6.4	1	11	10	70.4	10	80.4
Xylene	6.4	2	4	1	25.6	2	27.6
Toluene	5.6	2	3	1	16.8	2	18.8

B6.0 REFERENCES

BRE (1991) An Environmental Priority Setting Scheme for existing chemicals. Draft for Comment. Directorate for Air, Climate and Toxic Substances, Department of the Environment, July 1991.

CRC (1992) Handbook of Chemistry and Physics (73rd ed.) 1992-1993. Lide D R (ed), CRC Press Boca Raton, US. 16-22 - 16-24.

Shillaker R O (1992) Priority and Risk Assessment of Chemicals. Human Health Effects. In, Richardson M L (ed), Risk Management of Chemicals. The Royal Society of Chemistry.

ANNEX C ECONOMIC ASSESSMENT OF PROCESS AND ABATEMENT OPTIONS

C1.0 COST ESTIMATION PROCEDURE

171 If an operator justifies a proposed process option on the grounds of avoiding excessive costs of an environmentally superior option, then the economic implications of all feasible options should be compared. Appropriate standard financial techniques for project appraisal should be used to compare options. This is to be done by identifying the full costs of each process/abatement option, and annualizing them over the forecast period of plant operating life. The resulting figures enable comparison of options to be made in terms of the incremental equivalent annual costs of environmental improvements.

172 The Cost Estimation Procedure requires that, for each component technique of the process/abatement option, estimates be made of:

1) The capital costs of purchasing and installation.

2) The annual operating and maintenance (O & M) costs for a typical year (or, if expected to vary, over the lifetime of the abatement technique). Allowance may be made for lost sales due to any reduction in output. Costs should be net of any relevant benefits, savings or 'recovery credits' such as reduced use or increased recycling of energy or materials inputs, saleable by-products, reduced labour requirements, enhanced production efficiency or improved product quality.

3) The operating life, in years.

173 From this information a Net Present Value (NPV) for each option can be determined, with a suitable base year. This

involves discounting real values (i.e. in constant terms, excluding inflation) to the base year. The appropriate real discount rate is given by the opportunity cost of capital to the operator. This may be the real pre-tax marginal rate of return on private investment.

From the NPV, an 'equivalent annual cost' can be determined (the value of an equal annual payment throughout the project life, which gives the same NPV). This calculation is shown in Table C1.1.

Table C1.1 Equivalent Annual Cost of Pollution Control Equipment

1. Capital Costs (£)(1) : ____________
2. Discount Rate ("r") : ____________
   (expressed as a percentage, e.g. 10% = 0.10)
3. Operating Life of technique in years ("n") : ____________
4. Equivalent Annual Cost factor(2) : $\frac{r}{(1+r)^n - 1} + r =$ ____________
5. Annualised Capital Costs (Multiply Line 1 by Line 4) : ____
6. Yearly Recurring (Operating and Maintenance) Costs(3) : ____
7. Total Annualised Project Costs (Line 5 + Line 6) : ________

(1) If spread over one year, reduce to present value in first year

(2) Assumes payment at year end.

(3) Costs that recur less frequently than yearly should be pro-rated over the appropriate number of years. For example, pumps that are replaced once every three years, one third of the cost should be included in each year.

174 If necessary for clarity, a process/abatement option should be disaggregated into its component techniques, and the

equivalent annual costs found for each element before adding them together to give the cost of the process/abatement option. Equivalent annual cost estimates should be as accurate as possible, with all assumptions made explicit. The margin of error should not exceed thirty percent. Where operator's cost forecasts appear excessive or unreasonable, more detailed and comprehensive data may be required.

175 The base case must be clearly defined when examining options for an existing plant. Any costs of environmental protection and pollutant abatement systems which are necessary to comply with previous requirements must be included as part of the base case, not added to any of the potential BATNEEC process/abatement options.

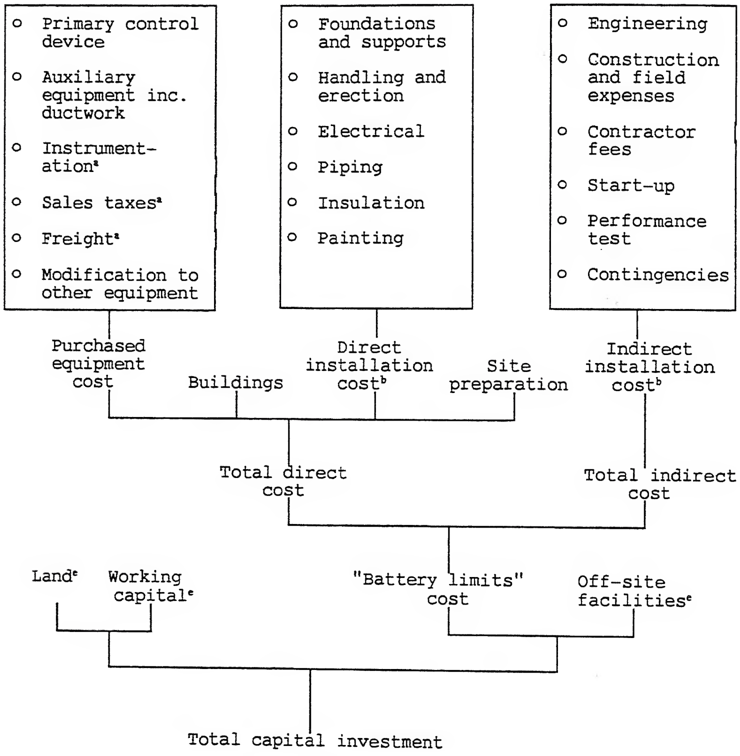
Further description of the procedure is provided below, using an end-of-pipe technology example.

C2.0 CAPITAL COSTS

176 Capital costs include all costs required to purchase equipment needed for the pollution control system (termed ***purchased equipment*** costs), the costs of labour and materials for installing that equipment (termed ***direct installation*** costs), costs for site preparation and buildings, and certain other costs which are termed ***indirect installation*** costs. Capital costs also include costs for ***land, working capital, and off-site facilities.*** These elements of capital investment are displayed in Figure C2.1. An illustrative example of how these costs should be presented is shown in Table C2.1

177 It is important that the limits of the area or process component to be costed are specified at the outset. This defined area is referred to as the battery limit for

Figure C2.1 Capital costs



a Typically factored from the sum of the primary control device and auxiliary equipment cost.

b Typically factored from the purchased equipment cost

c Usually only required at green field installations

d Unlike the other direct and indirect costs, costs for these items are not factored from the purchased equipment cost. Rather, they are sized and costed separately.

e Normally not required with end of pipe control systems.

Table C2.1 Capital cost estimate for an electrostatic precipitator

Item	Capital cost (£)
Direct Investment	
Equipment cost	
ESP unit	176,000
Ducting	64,000
Ash handling system	97,000
Total equipment cost	337,000
Installation costs	
ESP Unit	176,000
Ducting	102,500
Ash handling system	97,000
Total installation costs	376,500
Total direct investment (TDI) (equipment + installation)	713,500
Indirect Investment	
Engineering	71,300
Construction and field expenses	71,300
Construction fees	71,300
Start-up	14,300
Performance tests	3,000
Contingencies	188,900
Total indirect investment (TII)	420,100
Total turnkey costs (TDI + TII)	1,133,600
Working Capital	21,000
TOTAL	1,154,600

pollution control. Costs must relate to a process or activity defined by an acceptable battery limit. For a technique that is inherently less polluting, the battery limit may be the entire process or project. The cost of each major piece of equipment within the battery limit should be documented with data supplied by an equipment vendor or by a referenced source.

C3.0 YEARLY OPERATING AND MAINTENANCE COSTS

178 The recurring annual costs for pollution control systems consist of three elements, see Figure C3.1: *direct (variable and semi-variable) costs* (DC), *indirect (fixed) costs* (IC), and *recovery credits* (RC). These are represented by the following equation:

$$Yearly\ costs = DC + IC - RC \tag{C1}$$

179 The appropriate time period for these costs is one year, as this allows for seasonal variations in production (and emissions).

180 **Direct costs** are those which tend to be proportional or partially proportional to the quantity of emissions processed by the control system per unit time or, in the case of cleaner processes, the amount of material processed or manufactured per unit time. They include costs for raw materials, utilities (steam, electricity, process and cooling water, etc.), waste treatment and disposal, maintenance materials, replacement parts, and operating, supervisory, and maintenance labour.

181 **Indirect**, or "fixed", annual costs are those whose values are totally independent of the emission flow rate and which would in fact be incurred even if the pollution control system were shut down. They include such categories as overhead, administrative charges, insurance, and business rates.

182 Direct and indirect annual costs may be offset by **recovery credits**, taken for materials or energy recovered by the control system, which may be sold, recycled to the process, or reused elsewhere at the site. These credits, in turn, must be offset by the costs necessary for their processing,

Figure C3.1 Yearly (Operations & Maintenance) Costs

TOTAL YEARLY COST

Direct Costs

Variable Costs

- Raw materials
- Utilities
  - Electricity
  - Fuel
  - Steam
  - Water
  - Compressed air
- Waste treatment/disposal
- Labour
  - Operating
  - Supervisory
  - Maintenance

Semi-variable costs

- Maintenance materials
- Replacement parts

Indirect Costs

- Overhead
- Rates
- Insurance
- Administrative charges
- Capital recovery

MINUS

Recovery Credits

- Recovered product
- Improved product quality
- Useful byproduct
- Reduced labour, energy & materials

storage, transportation, and any other steps required to make the recovered materials or energy reusable or resaleable. They also include reduced labour requirements, enhanced production efficiencies or improvements to product quality.

183 Table C3.1 gives an example of annual costs for the electrostatic precipitator previously discussed (the figures are again illustrative). The discount rate is assumed to be 10 percent and the equipment life is 20 years. The relevant equivalent annual cost factor is then 0.1175 (i.e. 11.75%).

184 The labour and materials costs of any parts which will need replacement before the end of the useful life of the main plant must be subtracted from the capital cost figure before it is multiplied by the annualization factor. Otherwise, double counting would occur. Costs of these parts should be accounted for in the maintenance costs.

C4.0 USING REAL VALUES AND EQUIVALENT ANNUAL VALUES

185 Both the discount rate and all cost data should be in real, or constant, price terms rather than nominal, or cash, terms for the sake of consistency. Real values are expressed in money of a specified base year. This avoids distortions due to changes in the value of money resulting from inflation. If any prices are forecast to move differently from those in the rest of the economy (e.g. energy), they should be identified and the source of the forecast explained.

186 Private and social costs would be equal in an idealized, perfectly competitive economy with complete markets. In the real world, market imperfections affect the allocation of resources, and the costs to society of capital

Table C3.1 Electrostatic Precipitator: Equivalent Annual Cost Estimate

Item	Annual costs (£/yr)
Direct Costs	
Direct labour (£/man-hour)	26,500
Supervision (£/man-hour)	0
Maintenance labour (£/man-hour)	16,000
Replacement parts	5,000
Electricity (£/kWh)	4,000
Water (£/1,000 gal)	500
Waste disposal (£/tonne)	33,000
Total direct costs	85,000
Indirect Costs	
Overhead	
Payroll	8,000
Plant	12,500
Total overhead costs	20,500
Capital charges	
G&A, rates and insurance	45,500
Equivalent Annual Cost (11.75% of total turnkey costs)	133,000
Interest on working capital (10% of working capital)	2,000
Total capital charges	180,500
TOTAL EQUIVALENT ANNUAL COST	286,000

expenditure are often different from the private costs. In capital markets, the main disparity between social and private costs arises from taxation, and so the correct project discount rate is the real pre-tax marginal rate of return on private investment. If a company is unable to identify its marginal rate of return, then it may apply as a proxy the Treasury social discount rate.

187 Use of Equivalent Annual Values is necessary so that comparisons can be made between potential BATNEEC process/abatement options even if they have different economic lives. This is done by reducing all financial flows for each option to an NPV in the base year. Merely comparing NPVs between options with different economic lives would be misleading: two projects could have the same NPV but one might last twice as long as the other. The solution is to establish the equivalent annual value for each option, given by the discount rate and by the option's economic life. This then allows comparison between options on an equivalent annual basis. As mentioned above, cost estimating for each option may need to be broken down into the component techniques, which are finally summed to give the cost for each option.